505
J818
v.7

THE QUARTERLY

JOURNAL OF SCIENCE.

JANUARY, 1870.

I. LIGHT AND SOUND:

AN EXAMINATION OF THEIR REPUTED ANALOGY.

By W. F. Barrett, F.C.S., Natural Science Master at the London International College, &c.

Long before we knew anything of the origin either of sound or light, the existence of an analogy between these forces had been the subject of speculation by some philosophers. But the idea of such an analogy did not originate in philosophy; it was not confined to a few; it resulted in more than speculation. From the earliest times we find among all nations a crude perception of a similarity between sound and colour. This perception became rooted in their languages. The same words, in many cases, were employed to denote either light, or sound. A vivid impression received by the eye was equivalent to a forcible shock received by the ear: thus, the English "loud," the French "criard," the German "schreiend," are identical expressions, relating to sound, also applied to glaring colours. Faintness of vision and feebleness of voice were spoken of as one. Our own words *dim* and *dumb* were probably cognate terms in Anglo-Saxon.

It is easy to trace this correspondence in language much farther, but that is not our present business. Let us inquire if this widespread mental analogy between sound and colour rests upon a physical basis. Is it true that light and sound are alike, and if so in what way are they alike? How can the swift flash from a gun be said to resemble the sluggish report that follows? Except æsthetically, where is the likeness between a painting by Raphael and a theme by Beethoven?

At the outset let us remark that no attempt will be made to show the identity of light and sound: it is their resemblance, their *parallelism*, and not, of course, their oneness we wish to establish. A parallelism that probably is metaphysical as well as physical; so that the estimation of beauty of colouring and harmony of sound may, hereafter, be found to resolve themselves into mental actions

of Science

essentially the same. Here, however, we have solely to deal with the physical aspect of the question. In pursuit of our object it will be necessary to compare the principal phenomena of light and sound, and for this purpose it will be convenient to break up the subject into sections. If the analogy be just, it will assuredly gather strength as the comparison proceeds ; if it be false, then each section cannot fail to force this fact upon the mind. In either case the result ought to be profitable, if we simply seek the truth.

§ 1. Origin of Light and Sound.

Light and sound are both the products of vibratory motion. But to evolve light the motion must be enormously swift, whilst to produce sound the motion must be comparatively slow. In the former case only impalpable molecules can be made to attain the requisite swiftness—light is therefore a *molecular motion* of vibration. In the latter case visible masses of matter can be moved to and fro with the necessary speed: sound is therefore usually the product of a *molar motion* of vibration. Further, to continue the light, or to sustain the sound, the to-and-fro motion must be performed in equal times ; it must be *isochronous*. If not isochronous the light will be either intermittent or varying in colour, and the sound will be either a noise or musical notes of varying pitch.

Now comes a remarkable point. Sound and even music are usually produced by a disturbance very different from a vibratory motion. If we hit a tuning-fork on our knee, strike the strings of a piano, or pluck the strings of a harp, we produce music by rough mechanical means ; so the noise of hammering, the roar of cataracts, the whistling of the wind, or "the scream of a maddened beach," are all sounds, that is motions of vibration, produced by a rude motion of translation. Light, also, can be evolved by similar agency. The rubbing of two pieces of quartz or sugar, the sparks from a flint or steel, and the incandescence produced by the friction of meteors against the air are familiar examples of light generated by mechanical means.

How can we account for the transition from molar to molecular motion, from an impulse, such as a blow, to a regular pendulum-like swing? A well-established law of mechanics is no doubt the true explanation. This law may be stated as follows :*—"That if a body receive a shock and sufficient time be allowed to elapse so that the initial disturbance is destroyed by friction, imperfect elasticity and other causes, the final resultant motion will be vibratory and isochronous." Here, then, we have at once the explanation, and the analogy of the mechanical origin of luminous and sonorous vibrations.

---

* This appears to be a *fundamental law of the universe;* namely, that an original impulse of any kind finally resolves itself into periodic or rythmic motion. Does not this throw light upon the periodic motion of planets as well as the vibratory motion of atoms? Possibly, in some such way, we may hereafter learn to understand the musical *rôle* of nature.

It is possible, however, to produce sound as well as light by a *molecular* motion of vibration. This is the case when a wire or rod is rubbed longitudinally; and, as might be predicted, the sound thus obtained is far more shrill than when the same body vibrates transversely. Here, indeed, in longitudinal vibration, there are some striking points of contact between light and sound. For if a beam of polarized light be transmitted through a strip of glass, as soon as the glass, by rubbing it longitudinally, is caused to emit a sound, the light is powerfully affected.

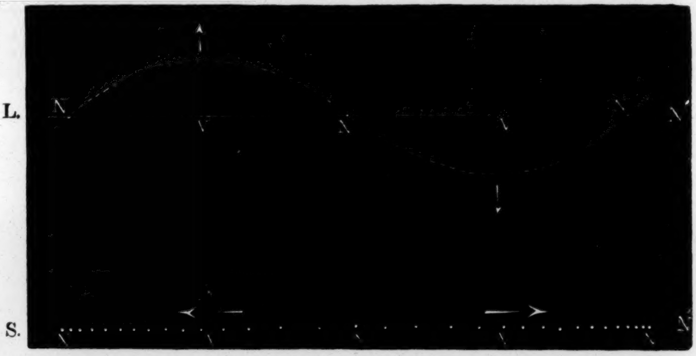
Light and sound have, further, a common origin in molecular change when they are generated by chemical action; thus light and more or less of sound attends combustion; and, directly or indirectly, sound and more or less of light attend the explosion of fulminating powders. Again, light is produced by electricity, as in lightning or the electric spark and electric light, and sound simultaneously accompanies each of these phenomena. Light attends the quick evolution of heat, and sudden heat is productive of the loudest sounds, as in the explosion of mixed oxygen and hydrogen gases.

Now, as light and sound are both the products of *motion*, the law of the conservation of force teaches us that neither one nor the other can have been produced without the loss of an equivalent amount of motion, that is force, elsewhere; and, moreover, that neither can have disappeared without the production of an equivalent motion or force of another kind. This being so, the doctrine of the correlation, or mutual convertibility, of the physical forces comes in and shows us the possibility, not at once perhaps but through intermediate steps, of exchanging light for sound and sound for light. As it is, already we know that the quenching of both light and sound, by absorbing media, results in the production of the same mode of motion, namely, that which we designate *heat*.

§ 2. The Propagation of Light and Sound.

Originating in vibratory motion, let us now inquire in what manner the forces of light and sound reach the eye and ear respectively. When a stick is allowed to swing to and fro in still water, the motion is communicated to the medium around, and a series of waves travel outward from the centre of disturbance. The motion, or *vis viva*, of the stick, though retarded and finally brought to rest by the friction of the water, is not lost. The movement has been delivered to the water, and part of it has reappeared in the form of the waves we noticed. The same considerations apply to light and sound. When a bell is struck its vibrations are delivered to the air around; a system of aerial pulses or waves is thus generated, which reaching the ear give rise to the sensation of sound. When a substance is made incandescent, the luminous vibrations do not throw the air into undulation; a finer and more elastic medium is requisite to accept and carry on molecular motion. We have abundant reason to believe that such a medium exists; we term it the *luminiferous ether*. To this ether, then, the luminous body communicates its motion. Here, also, a system of waves is produced which, striking the eye, finally give birth to the sensation of light. There is, however, this difference between the sound-waves of the air and the light-waves of the ether, that whereas the former move to and fro longitudinally, the latter vibrate transversely. A cornfield ruffled with gusts of wind exhibits waves like those of sound; the water of a lake thrown into ripples by a disturbance exhibits waves like those of light. The upper figure, L, in the accompany drawing (Fig. 1) shows a single plane-wave of light: the

Fig. 1.



lower, S, a single wave of sound. Each has at N its node, or place of rest, and at V its vibrating segment, or place of greatest motion. The sizes of the two waves are vastly disproportionate. The average length of a sonorous wave, say that of the middle C in the piano, is about 50 inches from N to N'. The average length of a luminous wave, say that of green light, is only the $\frac{20}{10000000}$th part of an inch from N to N'. This great difference must not stagger us in tracing out our analogy. The element of size does not enter into the region of law. The truth of this statement will become evident as we see laws obeyed in like manner by light and sound; by undulations, one set of which are millions of times the size of the other.

Another strong point in this analogy is presented by the phenomena of *Interference*. From an inspection of Fig. 1, it will readily be seen how this is produced. Let L be a series of waves; suppose a second series, of exactly the same length as L, to start just half an undulation later; it will be clear that the crest of one set will coincide with the hollow of the other. They will thus mutually destroy each other, and darkness will be the product of two luminous undulations thus related. In the same way one sound-pulse may obliterate another, and two sounds thus result in silence. If, for example, a vibrating tuning-fork, placed near the ear, be slowly turned on its axis, four times in each revolution, a position will be reached where no sound is heard. This occurs when the prongs are oblique in reference to the ear, and the waves generated by each prong exactly interfere. If the interference be only partial, *beats*, or intervals of sound and silence, will be produced.

Returning now to the sounding-bell: its motion chiefly spends itself on the air. Hence, when we remove the air from around a sounding body, the vibration continues far longer than otherwise it would. In such a case no sound is heard: internal friction finally brings the sonorous body to rest as a whole, and molecular motion or heat is the result. But in removing the air we do not, and we cannot in any way as yet known, remove the luminiferous ether; by which ether heat is propagated as well as light. Hence the heat-motion resulting from what originally was a sounding body at last escapes from the enclosure in the form of ethereal undulations.

Now when heat spreads by the ether in this way, we denominate it *radiant heat;* and, as we might expect, all the laws common to light are also common to radiant heat, for both are undulatory motions of the selfsame ether.* But whilst the propagation of light only takes place (so far as we yet know) by means of this ether, heat, on the contrary, spreads itself in two ways. It may be propagated from particle to particle by tangible matter, and the phenomenon is then termed conduction; or in waves by the ether, and the phenomenon is then, as we have seen, termed radiant heat. Now sound, like heat, may also be propagated by gross matter, and this likewise is called conduction; it may further, as already mentioned, spread itself in waves by the air, and in this form we may conveniently call it *radiant sound.* Light being only known in the radiant form, obviously it will only be in the phenomena of radiant sound that we shall be justified in further seeking the analogy to light. This we shall do in a succeeding section.

Here, however, it is important to note that we might expect an analogy between the phenomena of sound-conduction and heat-conduction. This is the case: taken in connection with the footnote below, considerable support is thus given to the analogy of sound and light. Broadly viewed, the best conductors of sound are the best conductors of heat, and *vice versâ.* Conduction in both cases is best through solids and worst through gases. Metals are the best conductors of sound and also of heat. In one very curious and well-established instance (though probably by no means the only one), the analogy runs very close. It has been observed that in wood *sound* is conducted with different facility in three directions. Lengthways, or along the grain, the conduction is best; across the rings or grain it is much worse; and tangential to the rings it is worst of all. Exactly the same facts, and in the same order, have been found to hold good as regards the conduction of *heat* in wood. But what is true of the conduction of heat is in every case, even in this last, equally true of the conduction of another force, namely, electricity. Now the conduction of electricity strongly resembles the conduction of sound; inasmuch that while the rate of propagation of *sound* through liquids is increased by increase of temperature, it is decreased in solids by the same cause. So likewise it is found that the same causes produce the same effects on similar substances in the rate of propagation of *electricity*. Thus, in the first place, we link light on to heat, and then heat on to sound; after that, heat on to electricity, and here, at last, electricity on to sound, whilst the connection between sound and light it is our object to set forth in this article. How this incidental fact opens up for a moment the oneness of the diverse forces which play around the world! We are encircled with wonder and with mystery, but every now and then facts such as these arise, which lead us to believe that perfect unity and simplicity lie somewhere in the back-ground.

---

* The selective absorption of radiant heat by various media (thermocrosis), the phenomena of calorescence—or the conversion of radiant heat into light—and the warming of a black surface by purely luminous rays, demonstrate the fact that radiant heat is only another phase of light.

§ 3. THE PERCEPTION OF LIGHT AND SOUND.

At first it would appear hopeless to seek for any analogy between organs so essentially different as the eye and ear. It must, however, be borne in mind that the functions of those organs are not only to receive the impressions of light and sound, but also to gather up and suitably present the wave-motion which impinges upon them. Owing to the vast difference in tenuity and elasticity of the media which convey light and sound, we should expect to find the very difference we observe in the apparatus contrived for hearing and seeing. Nevertheless it is possible to trace some correspondence of parts in the eye and the ear; and there have not been wanting physiologists who have pushed this view to a detailed and fanciful extreme. The reader who wishes for further information on this presumed resemblance of the two organs will find it given in a recent work by Dr. Macdonald,* to which we may have occasion again to refer.

But there is a remarkable analogy, very much overlooked, which appears to hold good between the perception of the respective impressions of light and sound. When we consider the multitude and complexity of the sounds we hear in a concert, and when we remember the extent, the diversity of colour and appearance of a landscape, it would appear almost inconceivable how such varied impressions could be individually conveyed to the mind. This intricate problem is solved in the most exquisite manner; moreover, in a manner that appears to be essentially the same in the case of the eye and the ear.

---

* 'Sound and Colour,' by Dr. Macdonald, F.R.S. Longmans, 1869.

Let us approach this analogy with an illustration. When a piano is opened an attentive listener will readily discover that every time a note is sung in the room, that string of the piano which would have yielded the same note is thrown into *sympathetic vibration.* If the note be changed, another and corresponding string responds. Imagine now that a deaf man has his fingers lightly touching the strings of the piano; he will perceive when they vibrate and which vibrates. He will thus become conscious what note has been sung. A similar arrangement to the foregoing is fitted within each of our ears. In the inner ear there is a contrivance known as Corti's organ, which consists of no less than 3000 differently strained fibres. These fibres constitute the outward extremity of the auditory nerve: a vibration of any one of them immediately travels to the brain. According to one of the greatest living investigators, Helmholtz, it is believed that one or more of the fibres enters into sympathetic vibration whenever a sound reaches the ear. Corti's organ is to us, therefore, merely a refinement and extension of what the piano was to the deaf man. M. Hensen's experiments upon the means of hearing in the crustacea confirm this view.

As, however, it would be impossible for the strings of a piano to vibrate if the note were beyond the range of the instrument in either direction, so also there is a limit to the perception of sound by the ear. If the aerial waves recur more quickly than 38,000 times a second, no sound at all is heard, however intense the vibration. If the waves recur slower than sixteen times a second, they are inaudible as a continuous sound. Hence the *extreme* range of our hearing embraces about eleven octaves. This limit varies slightly in different persons, as first shown by Dr. Wollaston.* For example, some persons whose hearing is otherwise good cannot hear the chirp of a cricket or the squeak of a bat. Moreover, one ear is often more sensitive than the other,† and some ears are more sensitive to one class of sounds than to others.

Now, with regard to vision, a similar arrangement to that in the ear appears to exist at the back of the eye. The optic nerve there spreads out to form the retina, upon the terminal filaments of which are scattered minute bodies, the so-called "rods and cones." Upon these bodies the luminous waves impinge, and it is considered probable that each accepts only that vibration which synchronizes with its own: in other words, that the perception of light arises from sympathetic vibration.* If this be the case, we should expect that the range of vision would, like hearing, fall within certain limits of pitch. This is well known to be the fact. Albeit the limit of vision is much more restricted than the limit of hearing; for with the utmost care we are unable to perceive vibrations of the ether beyond the range of an octave; that is, from the solar line A to L of the spectrum (see Plate). This extent needs, indeed, a practised eye; ordinarily the range corresponds to the interval termed a sixth in music, that is from the red to the violet extremity of the spectrum. The lower limit of vision, the extreme red, is produced by ethereal waves recurring 458 millions of millions of times each second; if the undulations be slower than this, they are invisible. The higher limit of vision, the extreme violet, is produced by luminiferous waves recurring 727 millions of millions of times each second; if faster, they do not excite the sense of sight. Inconceivable as is this rapidity, these figures are not hypothetical, nor merely probable; they express absolute facts incontestably established.

---

* 'Phil. Trans.,' 1820, p. 306.

† When travelling in Norway last year the writer observed that on one occasion the sounds from myriads of grasshoppers were heard, but on closing the left ear there was perfect silence: opening the left ear and closing the right ear, the sound was heard as loud as ever. The difference, where it exists, may readily be noticed by listening to the ticking of a watch. The cause, probably, arises from habitually sleeping on the right side.

Like the limits of hearing, so these limits of vision vary slightly with different individuals; some people are capable of seeing farther beyond the red and not so far into the violet, whilst the converse is true with others. Hence, beyond the shadow of a doubt, certain sounds and certain lights perceived by some persons are totally unperceived by others. And when we pass from human beings to the larger animals on the one hand, and to insects on the other, we doubtless have the range both of hearing and of vision considerably extended. We are not aware that the limits of vision in animals have ever been studied; but analogy and experience lead us to suppose that it differs from our own in many cases. Assuming that the perception of light is due to a sympathetic vibration of the filaments of the retina, it merely needs that these filaments should be capable of vibrating only the one hundred millionth of a millionth per second slower, and what we call black heat would be perceived as light: and if these filaments could vibrate the same amount faster, what we call the actinic or invisible chemical rays beyond the violet would become directly visible. Now it is highly improbable that the retina of every animal in creation should be, as it were, tuned to the same pitch as ours; and if this be so, then forces unrecognized by our senses are perceptible elsewhere.

The structure of the ear in a calf points to the conclusion that only the lowest sounds can be audible to that animal, but that its lower limit of hearing is beneath ours.* This is consistent with the doleful sounds made by that creature. Happily therefore for themselves, the lowing of cattle obviously produces a totally different impression upon their kindred to that which it produces upon us. Moreover, movements unheard by us are probably perceived as sound by them. If this be so at the lower limit of hearing, may not similar instances occur at the higher limit? It is perfectly conceivable, nay likely, that many insects produce and hear sounds far beyond our cognizance. And it would be most interesting to ascertain whether the organs of hearing in a bat, for example, or a grasshopper, correspond to the shrill sounds they produce.

---

* This suggestion was first made, we believe, by Melloni, in his 'La Thermochrôse.'

Returning for one moment to the illustration of the sympathetic sounding of a piano, we find that when its strings are thrown into vibration the motion takes time to subside. Hence we should expect to find a *lingering* in our perception of both light and sound, after the exciting cause had ceased. This is exactly what occurs. The retention of light upon the retina amounts to $\frac{1}{10}$th of a second. This retention causes a luminous point in rapid motion to appear as a line; the successive impressions blend into one. We cannot perceive as distinct from each other flashes of light that succeed each other at shorter intervals than the $\frac{1}{10}$th of a second apart. Similarly our ear cannot distinguish between a succession of similar sounds that follow each other at shorter intervals than the $\frac{1}{16}$th of a second. Like the blending into one of the colours on a spinning-top, the separate sounds link themselves together and constitute a musical note.

Radiant sound and light being both wave-motions, many laws are found common to both. When light falls upon a body it is either *transmitted*, *absorbed*, *reflected*, *refracted*, or *inflected*. The same phenomena can be observed when we substitute sound for light. Let us briefly examine this remarkable series of analogies.

§ 4. Transmission of Light and Sound.

Through transparent bodies *light* is transmitted freely. But if a series of transparent substances, each alternately differing in density, be placed together, the progress of light is obstructed, and may even be altogether stopped. Thus a perfectly transparent block of glass, if reduced to powder, is perfectly opaque. Air, a medium of different density, now intervenes between the particles of glass, and the light *echced*, as it were, from particle to particle is so weakened that it cannot struggle through.

In the same way *sound* in its passage is enfeebled, or even obliterated, if it pass through several media of alternately varying density. Wood transmits sound perfectly well, so does air, but if the wood be reduced to sawdust, sound is no longer transmitted. Thus cotton-wool deadens sound. Solid glass, salt, and ice, and all transparent solids transmit light and sound; reduced to powder, they are opaque both to sound and light. A glass of water transmits both light and sound, so does carbonic acid gas; but if the two be mixed, as in soda-water, a mixture nearly opaque to both light and sound is the result. By tapping a glass of soda-water during and after the effervescence the sound effect can readily be heard. The bubbles of gas break up the continuity of the water and render the sound emitted by the glass dull; when the bubbles have escaped, the ringing note of the glass returns. The same effect occurs in gaseous media. Humboldt, when journeying upon the plains of the Orinoco, noticed that columns of alternately hot and cold air enfeebled the passage of sound just as they lessened the passage of light. In the same way through fog, sound, like light, is propagated with extreme difficulty. The cause of this arises from the particles of water that are then suspended in the atmosphere, and by their presence produce variations of density.

---

* Savart: 'Annales de Chimie et de Physique.'

It has too been generally noticed that a good hearing day precedes wet weather, and before a wet day we generally notice the atmosphere becomes remarkably clear. This clearness has by an eminent physicist * been attributed to the fact that on ordinary days our atmosphere contains innumerable spores or germs floating in the air. At the approach of wet weather the little germs absorb the moisture, they become heavier and sink to the ground; thus the atmosphere is cleared from these solid particles which at the same time obstructed the free transmission of light, and interfered with the free transmission of sound.

§ 5. ABSORPTION OF LIGHT AND SOUND.

A black glass, or a black surface like velvet, absorbs the light that falls upon it. The light, as already observed, becomes translated into heat in the absorbing body. Woollen textures, curtains, and the like, are to sound what a dark glass is to light. Such obstacles stop the progress of the sonorous pulses, and also convert what was sound into heat. In the case of light there is further a *selective* absorption of certain rays; this gives rise to the colour of a body. Such selective absorption is a molecular act, probably due to the synchronism between certain luminous waves and the oscillations of the particles in their path. Hence selective absorption can only exist when there is a mixture of waves from which to select. Transferring these ideas from particles to a body as a whole, a corresponding selective absorption exists when there is a complex source of sound. If a bundle of different tuning-forks be struck, sonorous pulses of varying length will be emitted. Allowing this composite pulsation to fall on a single quiescent fork, only that pulse, which corresponds to the rate of vibration of the fork, will be absorbed, and by this means the hitherto silent fork will be thrown into vibration.

---

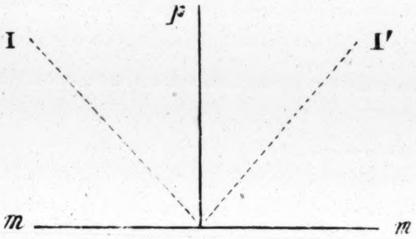
* De La Rive.

§ 6. Reflection of Light and Sound.

This is one of the best known, and at the same time one of the closest analogies between light and radiant sound.

When a beam of light, I, falls upon a polished surface, *m m*, it rebounds in the same plane, and at an equal angle on the other side of an imaginary perpendicular, *p*, drawn from the surface of the mirror. This is expressed by saying the angle of reflexion is equal to the angle of incidence. The same law is rigorously true for sound. It is easy to observe this reflexion from the sides of a cliff, a blank wall, or the roofs of churches. Echo is due to this reflexion of sound. Standing between two parallel mirrors, successive and gradually fainter reflexions of the body will be seen. The same is true with regard to sound, as can be observed when speaking between two perpendicular walls, sufficiently distant from each other.

Fig. 2.



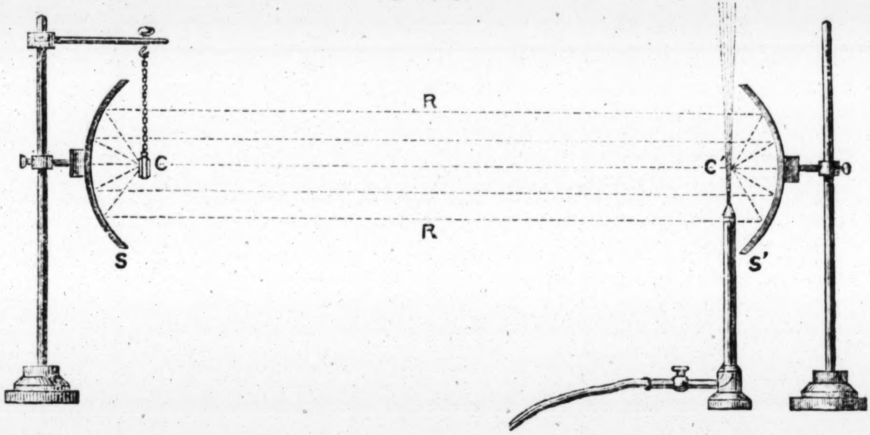
Under certain conditions light is "internally or totally reflected," as it is termed; that is, at a considerable obliquity of incidence light cannot emerge from a dense medium into a rarer one: this may be well observed when a glass rod is made red hot at one end, the distant extremity glows by internal reflexion. In the same manner sound can be internally reflected. When a sound made under water strikes the surface of the water very obliquely, the greater part of the sound is unable to escape into the air, owing to the total reflexion occurring at the upper surface of the water.*

With curved reflectors sound is affected in the same way as light. A sound-focus or a sound-image may be obtained by a concave reflector. The following lecture illustration of this fact was shown by the writer two years ago at the Royal Society of Dublin. Two parabolic mirrors S S were placed as in Fig. 3. At C, in the focus of, S, a watch is suspended; in the conjugate focus C′ of the other mirror, S′, a sensitive flame was caused to burn. The flame moves at the slightest sound. The light rays R R from the flame are rendered parallel by s and converged upon the watch by s, where a brilliant spot of light is seen. Similarly the sound-waves from the ticking of the watch follow the opposite course,

---

* This fact has been established by the experiments of Colladon and Sturm on the Lake of Geneva.

FIG. 3.



and an acoustic focus is cast upon the flame. The flame throbs in exact time with the beats of the watch. Moving the watch or the flame nearer together places them out of the focus, and the flame by its stillness announces the fact.

It is easy for any one to repeat this experiment with very homely apparatus. Circular dish-covers of earthenware or metal may be used as mirrors, and for the flame may be substituted a little funnel with a short tube leading to the ear.

§ 7. REFRACTION OF LIGHT AND SOUND.

Light on passing from a dense medium to a rare one, or *vice versâ*, is bent out of its original course. So also is sound. Light may by refraction be converged and focussed by lenses. Sound-lenses may also be made.* Filling a thin india-rubber balloon with a dense gas, like carbonic acid, a double convex acoustic lens is produced. By means of such an arrangement divergent sound rays, from, for example, the ticking of a watch, can be converged and focussed. Placing a sensitive flame in the focus, this refraction of sound may be rendered apparent to a large audience.

§ 8. INFLECTION OF LIGHT AND SOUND.

This is an effect produced upon divergent waves merely by the presence of an obstacle in their path. When a sea-wave meets an isolated rock it breaks, spreads itself around the rock, and clasps itself again at a short distance behind. Thus only comparative rest is found behind such a breakwater. Similarly a sonorous wave meeting an obstacle, say a large pillar, girdles the pillar and thus partially destroys the sound-shadow which such a pillar would otherwise throw. In former time it was urged that if light be a wave-motion, there ought also to be inflection and only partial shade behind an opaque object. The inflection of light has since been discovered; light *does* slightly encroach, in the form of fringes, upon the shadow cast by an object. Nevertheless, owing to the rectilinear propagation of light, shadow is a characteristic feature of light. Is there an analogous sound-shadow? There is, notwithstanding inflection. If we pass close beside a church, the bells of which are ringing, we shall notice that on coming beneath the tower we enter a region, nearer the source of sound, yet where the sound is very perceptibly less audible; and as we gradually emerge from this acoustic shadow the sound grows louder. So also when listening to an approaching train, as it is occasionally hidden from view, accompanying sound-shadows flit across the ear. And in a more elastic medium than air, such as water, sound-shadows would, necessarily, be more intense and sharply defined.

---

* As first demonstrated by Sondhauss.

§ 9. Harmony of Colour and Music.

It is in this division of our subject that we find a wide-spread and tacit acceptance of the analogy of light and sound. We instinctively criticize in like terms the works of a painter and a musician. We speak of the harmonious blending of colours in a picture, as we do of the chords in a musical composition. We compare, apparently without reason, the order of colours in a rainbow to the notes of the gamut. Like Locke's blind man who said scarlet was to him as the deep sound of a trumpet, we think of red as a low note, of blue as a high one. We find, as a rule, that good taste in art goes hand-in-hand with good taste in music; hence a large number of eminent painters have been excellent musicians.* All this points to the fact that pleasure given to the eye or ear evokes similar mental impressions.

Now the question arises, Has all this æsthetic oneness of colour and music any physical foundation, over and above that general analogy we have so far traced between light and sound? We believe the following considerations will show not only that it has some foundation, but that the analogy is far more wonderful than has hitherto been suspected.

Let us take as our standard of colours the series given by the disintegration of white light, the so-called *spectrum*. As our standard of musical notes let us take the natural or *diatonic scale*. We may justly compare the two: for the former embraces all possible gradations of simple colours, and the latter a similar gradation of notes of varying pitch.

---

* Omitting many living painters, of whom this is true, it is sufficient to name Tintorretto, Caracci, Salvator Rosa, Dominichino, Guido Reni, Leonardo da Vinci; and Rubens also is said to have been passionately fond of music.

Further, the succession of colours in the spectrum is perfectly harmonious to the eye. Their invariable order is red, orange, yellow, green, blue, indigo, violet. Any other arrangement of these colours is less enjoyable. Likewise the succession of notes in the scale is the most agreeable that can be found. The order is C, D, E, F, G, A, B.* Any attempt to ascend or descend the entire scale by another order is disagreeable. The order of colours given in the spectrum is exactly the order of luminous wave-lengths, decreasing from red to violet. The order of notes in the scale is also exactly the order of sonorous wave-lengths, decreasing from C to B.

The interval of wave-lengths embraced between the extreme colours of the visible spectrum is ordinarily as the ratio of 1:0·57, corresponding to the interval known as a seventh in music. But the writer is well informed that by proper means further limits can be seen, *viz.* from what is known as the solar line A to the solar line L.† (See upper figure in Plate: L is not shown.) The wave-length of A is 76, and of L is 38 hundred-thousandths of a millimètre, or as the ratio of 1:0·50, corresponding to the interval of an octave in music, or just the range of the scale.

Arbitrarily placing C under the colour at the solar line A, *viz.* a deep brownish red, then the octave higher of C would fall under whatever colour is found at the solar line L, *viz.* a lavender grey. Now comes this important question, *Are the intermediate colours of the spectrum produced by vibrations that bear a definite ratio to the vibrations giving rise to the intermediate notes of the scale?* According to our knowledge up to this time, apparently not.

In an ingenious little work by Dr. Macdonald, before alluded to, an attempt has been made to establish this analogy indirectly;‡ but if direct comparison fails, it is useless to push the matter farther. Newton himself sought for this analogy between note and colours, but he only found the relative spaces occupied by each colour in the spectrum to be similar to the relative intervals of musical notes. This is, obviously, a false analogy. We must compare wave-lengths of light with wave-lengths of sound; not, of course, their actual lengths, but the *ratio* of one to the other.

Until very recently it has been impossible to do this accurately. New maps of wave-lengths of the different parts of the spectrum have, however, of late appeared.§ Let us reduce the newest and best determinations of wave-lengths to a common ratio, and compare the result with the wave-lengths of the notes of the scale reduced to the same ratio. Here are the limits of wave-lengths of the different colours of the spectrum as most carefully determined by Prof. Listing.* In the third column the writer has added the mean wave-length of each colour, and in the fourth column the ratio of one colour to another, taking the mean wave-length of red as 100.

---

* The fact that Newton saw seven colours in the spectrum, and there are seven notes in the scale, is only an accident; the number of colours, or tints, entirely depends on the judgment of the observer.

† This is on the authority of Mr. Crookes, who has on favourable occasions seen the spectrum extending this length, where a quartz train of lenses and prisms was employed.

‡ It is a pity this brochure of Dr. Macdonald's is so disfigured by its typography, it is also too speculative and dogmatic.

§ The most recent by Thalen. 'Transactions of Royal Society of Upsala,' 3rd Series, vol. vi.; also 'Annales de Chimie et de Physique,' Oct., 1869.

TABLE OF WAVE-LENGTHS OF COLOURS IN THE SPECTRUM.

	WAVE-LENGTHS: IN MILLIONTHS OF A MILLIMETRE.		
Name.	Limit.	Mean.	Ratio.
Red	723 to 647	685	100
Orange	647 to 586	616	89
Yellow	586 to 535	560	81
Green	535 to 492	513	75
Blue	492 to 455	473	69
Indigo	455 to 424	439	64
Violet	424 to 397	410	60

Here next is a table giving the middle notes of the scale, their wave-lengths, and their reduction to a common ratio, taking C as 100.

TABLE OF WAVE-LENGTHS OF NOTES OF SCALE.

Name.	Wave-length in inches.	Ratio.
C	52	100
D	46⅓	89
E	42	80
F	39	75
G	35	67
A	31	60
B	27½	53
C_2	26	50

Putting together the two ratios, the following remarkable correspondence at once comes out:—

RATIO OF WAVE-LENGTHS OF NOTES COMPARED TO RATIO OF WAVE-LENGTHS OF COLOURS.

Notes.	Ratio.	Colours.	Ratio.
C	100	Red	100
D	89	Orange	89
E	80	Yellow	81
F	75	Green	75
G	67	Blue and indigo (mean)	67
A	60	Violet	60
B	53	[Ultra violet	53]
C	50	[Obscure	50]

Assuming the note C to correspond to the colour red, then we find D exactly corresponds to orange, E to yellow, and F to green. Blue and indigo, being difficult to localize, or even distinguish in the spectrum, they are put together: their mean exactly corresponds to the note G. Violet would then exactly correspond to the ratio given by the note A. The colours having now ceased, the ideal position of B and the upper C in the spectrum are calculated from the musical ratios. This coincidence, as unexpected as it is perfect, is represented in the two upper figures on the Plate.*

---

* Poggendorff's 'Annalen,' vol. cxxxi., p. 564.

Had space permitted, we should have ventured to trace out to some extent this common harmony of colour and sound. All we can do is to point out a few suggestions that occur at once.

Every one knows that the juxtaposition of two colours nearly alike is bad, and it is well known that two adjacent notes of the scale sounded together produce discord. Selecting and sounding together two different notes we may produce either discord or harmony; so with the juxtaposition of certain colours, either pleasurable or painful effects are produced. Thus—the notes D and E, together, are bad; so are orange and yellow when contrasted. C and G harmonize perfectly, so do red and blue. C and F is an excellent interval, so is the combination of red and green. Now, on referring to the Plate, it will be seen that the foregoing notes exactly underlie those very colours that we have named with them.

But, further, it is possible to obtain a real optical expression of the musical intervals.† By reflecting a beam of light from one vibrating tuning fork to another placed at right angles, curves of light are obtained, which vary according to the combination of forks we select. The most perfect harmony, *viz.* two notes in unison, gives the simplest curve—a circle. The next most harmonious interval, an octave and its fundamental note, gives the figure of 8; the next, the interval of a fifth, gives a more complete figure, and so on. The complexity augmenting as the concord lessens. Some of these curves are shown on the lower figure in the Plate. By the side of each curve is put the musical notes from which it was derived, and for the sake of comparison the colours which would correspond to each interval are also brought down. It will be seen that harmony runs throughout.

A musical chord thus becomes both a representative picture, and an acoustic painting, whilst the musical scale is literally a rainbow of sound. It is hardly too much to say that we might possibly translate into a musical melody a sunset, a flower, or a painting by a Rubens or a Raphael.‡

But here let us check our imagination. We have throughout the foregoing article endeavoured to avoid overstating the analogy. Let us now be careful lest we become victims of the "*idola tribus,*" lest we strive to impose on nature a greater degree of simplicity than her facts will justify.

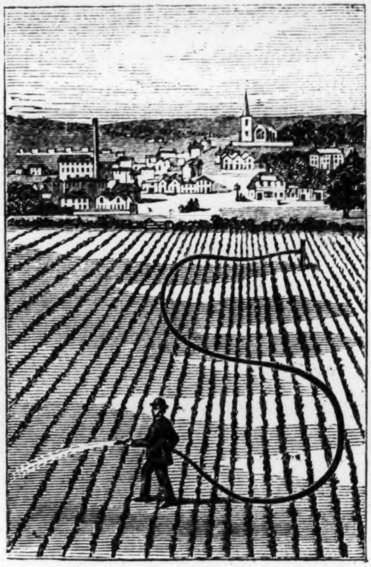
---

* There will be noticed over the spectrum on the Plate a scale of actual wave-lengths, by which the remarkable but natural crowding together of the colours at the red end is well seen.

† First accomplished by M. Lissajous.

‡ On this subject an able article by Mr. C. Seth Smith, recently appeared in the 'Builder.'

II. ON THE PRINCIPLES AND METHODS OF SEWAGE IRRIGATION.



SEWAGE utilization is perhaps one of the most hotly-debated subjects of the day, and frequent references to it have from time to time appeared in the pages of this Journal. These will be found repeatedly in the Chronicles of Science (Agriculture), and in two articles, entitled respectively "Sewage and Sewerage,"* and "On the application of Sewage to the Soil,"† wherein the progress made in the development of works for sewage irrigation purposes has been recorded. Our present object is to give a brief account of the best means for carrying out irrigation works for the disposal of town sewage, and of the laying out of lands preparatory to the application of sewage, so far as they can be deduced from the results of past experiments, and from works hitherto constructed and brought into operation in different parts of the United Kingdom. We shall, however, preface our remarks on the above-named subjects by a reference to one or two points in connection with them, with the view to show that the present movement in favour of utilizing our town sewage is but the revival of a practice of great antiquity, which, owing to numerous causes, has, for many centuries, been abandoned and perhaps forgotten.

The recognized power of earth to act as a disinfectant may first be traced to the Mosaic lawgiver, but it is not improbable that it was applied to that purpose before the departure of the Israelites from Egypt, and that the injunction for it to be so used whilst they were on their wanderings was but a law for the observance of a then well-known sanitary precaution. The filth of Jerusalem was, it is recorded, at one time burnt in an oven in the valley of Hinnom, which also served for human sacrifices, and was called "*tophet*," from "*toph*," a drum, used on such occasions to drown the cries of the victims. At a later period, however, when the Mosaic religion was restored, the Temple purified and rebuilt, and the country began to prosper under the protectorate of powerful neighbouring nations, large sewers and aqueducts were constructed, which still exist, owing to the fact of their being cut in the solid rock upon which the city was built. Eusebius, who was a native of that country, and died about the year 340, mentions Timocrates, the surveyor of Syria, by whom the city was throughout provided with water. The water used for flooding the court of the Temple, to wash away the offal and blood of the sacrifices, drained into a pit, now called "The Fountain of the Virgin;" from whence, after mingling with the town sewage, it was conducted to a second one, now called the Pool of Siloam—but which, it is thought, is not the one formerly known by that name—and thence to the king's garden, for purposes of irrigation. These pits served, no doubt, as settling-tanks to collect the solid matter; and thus, in their general arrangement, we can perhaps trace the earliest recorded attempts at utilizing sewage, and one which, so far as our information goes, does not appear to have differed materially from the most approved practice of the present day.

---

* 'Quarterly Journal of Science,' 1866, p. 180.

† Ibid., 1867, p. 357

The difficulty in getting rid of night-soil and refuse in large towns by any other method has necessitated the adoption of sewers and water-carriage for that purpose, and with our present knowledge on the subject it does not appear probable that sewers will ever be superseded. "It matters not," remarked Mr. Bailey Denton in a recent letter to 'The Times'* newspaper, "whether the earth-closet system of excretal sewerage gains ground in places where advantageous circumstances suggest its adoption, sewers must exist in every place where habitations are congregated together, whether it be a city or a village, for the discharge of liquid refuse from the chamber, the bath, and the kitchen, independently of the excrements of the closet, which form in reality but a small proportion of the entire refuse of the dwelling." The introduction of sewers in places has, as might naturally be expected, led to their being used also as drains, and the result appears to have been satisfactory, although the reports by the Medical Officer of the Privy Council tend to show "that where a system of separating the sewage of dwellings from the water of the soil on which they stand has been adopted, and the sewerage and drainage can be discharged by different channels, the maximum of success may be achieved." On the other hand, Mr. Denton states that "wherever sewerage and drainage—which have different sanitary effects, and ought to be distinct operations—have not been carried out together, intentionally or accidentally, the operations have failed, more or less, in the purposes for which they were designed."

The mixture of water with sewage is looked upon by some agriculturists as a great drawback to its application. Apart, however, from water-carriage being the cheapest, as well as the most convenient form of removing the sewage of towns, it is of value in distributing it, and enables the operation of spreading solid manure over the face of the earth, which must otherwise take place, to be dispensed with. By the process of irrigation, too, fertilizing matter is distributed over the land with uniformity, and it is presented to the plant in such a state that it is at once ready to be assimilated, that is, it is at once food for the plant; the plant grows more rapidly, the period of growth is greatly shortened, and, consequently, we get a greater number of crops in a given period, under the irrigation system, than could possibly be obtained under any process of dry manuring. The quantity of water mixed with the solid matters in the ordinary sewage of towns is very great, and it has been estimated that, including rainfall, 350 parts of water are employed in removing one part of excrement; thus the sewage is delivered to the land in a very diluted state, but, as has been proved by results, by no means too weak for useful application. The strength of pure sewage would be far too much for vegetation, and, instead of improving it, would tend utterly to destroy it; but thus diluted it is reduced to a state in which it appears to be most readily absorbed by the earth, and thence taken up by plants as it is required for their nourishment.

---

* 'Times,' October 28, 1869.

In order to meet the requirements of local circumstances, where land is not available for purposes of irrigation, attempts have from time to time been made to separate the solid particles from the fluid, the former being made into a species of artificial manure, whilst the latter is allowed to pass away into the most convenient channel for its escape. The value of the manurial ingredients held in solution, being to that contained in the solid portions as six to one, the great fertilizer ammonia also being afloat in the liquid portion, it is not to be wondered at that these experiments have invariably failed, and the works erected for carrying out the different processes have, almost without exception, been abandoned. After filtration, the general plan has been to mix the solid residuum with dry rubbish, town ashes, charcoal, or other bases for forming a solid substance; the unwillingness, however, of farmers to purchase this manure at a remunerative price to the manufacturers, and often their refusal to pay for it at all, necessarily led to the early closing of all works constructed for the purpose of its manufacture.

In order to counteract the loss of valuable manurial ingredients which, under the above processes, passed off with the liquid portions of the sewage, recourse was next had to the use of chemical reagents with the view of causing a precipitation of those fertilizing ingredients which are held in solution, and for this purpose use has been made of lime, sulphate of alumina, soluble phosphate of magnesia, perchloride of iron, &c.; but as none of these have been successful in causing a precipitation of ammonia, or any other manuring substance, it is needless to enter here into any further details regarding these experiments. Suffice it to state that no attempt hitherto made to extract a useful manure from sewage which could be applied in a solid form has proved anything but a failure.

The Commission appointed by the British Association to report "On the Treatment and Utilization of Sewage," states, with reference to the treatment of liquid sewage, that at fifteen of the places which are sewered, wholly or partially, the liquid sewage is subjected to treatment either by allowing it to remain for a time in settling-tanks, from which the deposit is occasionally removed, as at Burton-on-Trent, Birmingham, Epsom, Farnham, and Andover, or by filtering, as at Uxbridge and Ealing. In eight instances deodorizing materials are added, such as lime and carbolic acid, as at Carlisle and Harrow. Lime alone is used at Leicester; lime and chloride of lime at Luton; perchloride of iron at Cheltenham; perchloride of iron and lime at Northampton; ferruginous clay wetted with sulphuric acid at Stroud; and at Leamington the lime treatment has lately been superseded by the A, B, C, method proposed by Messrs. Sillar and Wigner. By this treatment the sewage is clarified, and a deposit is separated which is sold as manure.

In regard to the effects thus produced, it is stated that at Leicester the sewage runs off as pure as ordinary rain-water; at Ealing it is said to be free from smell, colourless, and harmless to vegetable or animal life; at Stroud and Luton the effect is stated to be satisfactory; at Harrow the nuisance is said to be somewhat mitigated; and at Abergavenny the stench is said to be abated by the treatment of the sewage; at Bury St. Edmunds upward filtration through charcoal and gypsum has been abandoned in favour of costly irrigation; at Banbury treatment of the sewage has failed; at Hereford, where it was proposed to be adopted, it has not been tried on the score of expense; at Tunbridge it is about to be tried; and at Hastings and Cambridge experiments are being made.

With regard to the relative advantages of solid and liquid manure, supposing even that all the fertilizing properties of sewage could be retained in a solid form, we cannot perhaps do better than to quote the following extract from the 'Minutes of the General Board of Health relating to Drainage and Sewerage of Towns, &c., 1852,' by whom the question seems to have been satisfactorily set at rest:—"It is established by wide general experience that drained land does not deteriorate, but increases in fertility, and maintains its increased fertility from year to year, though washed through and through by all heavy falls of rain carried away by the drains. The rationale of this fact was displayed in the experiments prosecuted by Professor Way, which show that upon the application of manures in the liquid form the fertilizing elements do not escape through the soil, but are retained by it chemically. On the other hand, where manures are applied as top-dressings in the solid form, it is proved by experience that after heavy showers of rain the solid manure is washed away, bodily as it were, into the ditches and watercourses; so that whilst the outfalls from land top-dressed and undrained are turbid with the matter carried away, and complained of as a nuisance, the outfalls from drained land, richly manured with the liquid, discharge pellucid streams."

Liquid sewage has a special value distinct from the fertilizing matter it contains, and also from the water that transports it; and this is its temperature. The value of this peculiar property cannot be over-estimated in a country similar to this, in which extreme changes of atmospheric temperature often take place suddenly, and injuriously affect both plants and animals, and this is more particularly demonstrated in the depth of winter and during long and continuous frosts. "It is a rather remarkable circumstance," observes Mr. Baldwin Latham, "that when the greatest degree of temperature is required the sewage possesses it, that is, the temperature of sewage has been found by the author to increase with the period of duration of frost. This is probably owing to the stagnation of surface-water, and also to the habits of the people, as much less cold water is used in the depth of winter than at other times. So great is the value of temperature, that a crop under sewage irrigation may be seen growing even at the time of a severe frost."

It does not appear that there exist any soils to which sewage irrigation may not be beneficially applied. That portion of the Craigentinny Meadows at Edinburgh known as Figgate Whinns, consists of absolutely pure sand, whilst the soil of other parts is a good loam passing into a strong clay; the former, which was originally worthless, now produces grass crops which sell at from 20*l*. to 28*l*. per acre per annum, thus showing that no land can be too poor for profitable cultivation where liquid sewage is obtainable in sufficient quantity. A larger amount of sewage is required for light than for heavy soils, particularly during the first year of its application; and clay appears of all others to possess the peculiar property of separating the manurial ingredients more completely, and of retaining them better, than any other soil, and it is consequently found that the crops grown are much heavier, and that altogether clay soils produce a far better result than those of a light, sandy nature. Gravelly soils require a certain time to become thoroughly saturated with the sewage, and absorb it greedily while the operation is in progress.

The value of a good system of drainage in all agricultural land is sufficiently understood at the present day; but if it be beneficial under ordinary circumstances, it is absolutely necessary where irrigation is adopted, especially in heavy soils. "I have no doubt," says Mr. Denton, in the letter above referred to, "that in cases of sewage applied by way of irrigation to the surface of undrained clay land, or to water-logged free soil lacking natural drainage, the earth will become sodden, and liable to create a malaria; but with a perfect system of under-drainage (designed with relation to surface irrigation) at the first description of soil, and natural drainage in the second, sewage-irrigated land may be rendered perfectly harmless." From time to time complaints have been raised that land irrigated with sewage-water was offensive to the surrounding neighbourhood; the observations of the British Association Commission, however, tend to prove that in most cases the application of the sewage for irrigation has not been attended with any apparent change in the sanitary condition of the district, whilst in several instances there has been a marked improvement. Generally speaking, too, no objection appears to have been made to the application of sewage in this manner, and where such objections have been made, on the ground that the application was offensive and injurious, they do not appear to have been supported by medical authorities, and in several instances they have ceased.

The quantity of sewage that may be applied with advantage to an irrigated area in the course of the year has been closely investigated by Mr. Latham, and as the results of his calculations agree entirely with the experience obtained at Croydon, and with the experiments made by the Sewage Commission, we give them here as being probably the closest approximation to exactness yet obtained. Where it is considered desirable to apply as much sewage as will be sufficient for the growth of a grass crop, without drawing on the resources of the soil, 3645 tons of sewage per acre per annum will be required to grow 30 tons of grass, 4860 tons of sewage for a crop of 40 tons of grass, and 6075 tons for one of 50 tons of grass. If, however, the soil will provide half the potash required, then, to grow 30 tons of grass per acre, there will be required 1837 tons of sewage; to grow 40 tons of grass per acre, 2450 tons of sewage; and to grow 50 tons of grass per acre, 3062 tons of sewage. As 40 tons of grass per acre may be considered as easy of production on a properly-regulated irrigated area, and as it would not be desirable to exhaust the soil of any of its constituents, Mr. Latham considers that 4860 tons per acre may be said to be the right amount of sewage, and this closely assimilates with the conclusions arrived at by the Sewage Commission, who reported that 5000 tons of sewage per acre per annum was the right amount to apply in order to get the greatest results.

The actual value of town sewage yet remains, to a certain extent, an open question, but it may be accepted as a universal rule, that only under the most exceptionally favourable circumstances can the sale of it afford any adequate return upon the cost of constructing sewage works; so that, however profitable its use may be to the farmer, it cannot be relied upon as a source of much income to the town whence it is obtained. The theoretical value of sewage has been calculated by some of our most eminent chemists and others, and the results arrived at vary from 1*d.* to upwards of 2*d.* per ton. Practically, however, it has been found that this is too high, and that its real value—that is to say, the price which a farmer could afford to pay for it—does not exceed from ½*d.* to 1*d.* per ton, and in estimating the probable returns from the sale of sewage it will always be safer to adopt the lower figure.

The cost of the application of sewage for irrigating land appears to be dependent on a number of local conditions, and, consequently, to vary considerably. It would seem, from the data collected by the Commission appointed by the British Association, that in many instances the outlay requisite for this purpose would exceed what a farmer could be expected to incur, and that in such cases, at least, it would be proper to regard this outlay as coming under two distinct heads, *viz.* that which a town may reasonably be expected to bear for the mere object of getting rid of its refuse, and that which a landowner or farmer may be able to incur for the improvement of his land. It is probable that when viewed in this light the application of liquid sewage to land would become a source of revenue to towns only under special favourable circumstances, but that, in opposition to the opinions which have been somewhat hastily formed in certain cases, it will more frequently entail some amount of expenditure on the towns themselves. At the same time the benefit to land and the improvement in the condition of rivers to be realized by this mode of dealing with liquid sewage can scarcely be matter of doubt or uncertainty any longer.

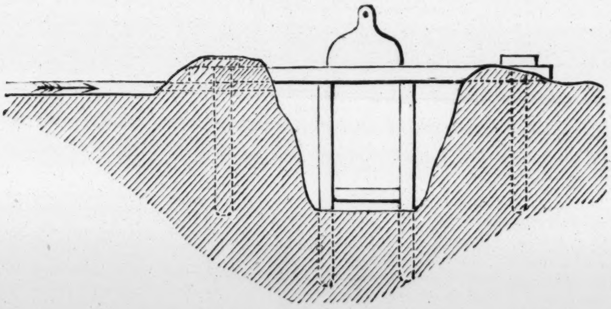
For carrying out a system of irrigation it is necessary, of course, that the sewage should, in the first place, be brought by channels or drains to the neighbourhood of the fields to be irrigated, where the more solid parts are separated from the liquid by allowing it to settle for a time, or, as is more generally the case, by a coarse system of filtration. For the distribution of the liquid, four different methods have been applied, *viz.:* 1. That known as the hose and jet system. 2. Sub-irrigation, or the distribution of the fluid below the surface of the ground. 3. By means of surface channels. And, 4. By total submersion. In deciding, however, which is the best system for distributing sewage, two things should be kept in view: the first is that all arrangements for its distribution should be as simple and inexpensive as possible; and the second, that owing to the constant quantity of sewage to be dealt with, the arrangements must be capable of being worked at all times and seasons. With these preliminary remarks we proceed now to describe briefly the principles upon which the different methods of distribution, above referred to, are carried out.

1. *The Hose and Jet System.*—The fatal objection to this system is that it is not capable of application at all seasons. In laying out works for the purpose, the sewage must, in the first instance, be brought into the field by means of underground pipes, which must also be laid in a sort of network over the whole grounds to be manured, to which pipes with couplings or hydrants for attaching a hose are fixed at certain points (see Vignette). In all cases where the hose and jet system is applied, the sewage must be delivered under pressure to enable it to be distributed over the field at a considerable altitude above its surface, as well as to overcome the friction in the pipes, and a head of from 10 to 12 feet is necessary where the sewage is delivered by the force of gravitation. Where a natural fall cannot be obtained, pumping becomes necessary, and this adds considerably to the cost. One great objection to the hose and jet system is that sewage cannot be applied to crops by it except at the earliest stages of their growth, owing to the necessity for dragging long lengths of hose over the land; it is therefore quite inadmissible when the crop has grown to any considerable height. Besides, by this mode of application the sewage is sprinkled over the crops, falling upon them as a shower, instead of being applied to the roots, which, though it would be unimportant and harmless were pure water only used, becomes actually injurious to vegetation in the case of sewage irrigation, by leaving certain deposits upon the leaves and stems of plants, which clog their pores and check growth. The system has enjoyed a partial success on the farms of Mr. Alderman Mechi and Mr. Nelson, but at Rugby, and other places, it has totally failed, and been abandoned. Mr. Rawlinson has stated that it would cost more to distribute 500 tons of sewage per acre by the hose and jet than it would to apply 5000 tons by surface channels.

2. *Sub-Irrigation.*—Under this system porous pipes, or tubes perforated with small holes, are laid under the ground at such a depth as to be beyond the reach of the plough, through which the sewage-water is forced. In some instances the pipes that are used for drainage may be made use of for this purpose by merely stopping up their outlets during the time that they may be required for irrigation, by which means the water will be dammed back until it reaches the upper stratum of the earth and the roots of the plants. This system has been practised in Switzerland to a limited extent; it is, however, expensive, and is open to the objection that it tends to raise the water in the land to the level of the soil, and the earth thus becomes water-logged, in addition to which it is attended with a great waste of fertilizing matter owing to the depth at which the sewage is delivered below the surface, a part of it gravitating still lower into the earth, and only a portion reaching the roots of the plants.

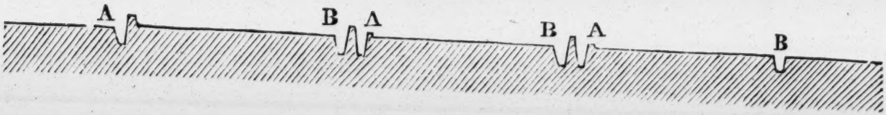
3. *Surface Channels.*—For the purpose of distributing sewage by means of open carriers, or surface channels, it may, if desirable, be brought to the head of every field in a covered channel, or it may be permitted to flow through open ditches, as may be most convenient. This system, which is the simplest and most effectual, may be carried out in various ways, according to the configuration of the land. By it sewage can be at all times applied to the plant, as it merely runs in a thin film over the surface of the ground at its root; but in all cases it is necessary that the land be specially prepared for the sewage by careful levelling, and otherwise according to its natural contour. This may be done in three ways, which are respectively known as the pane and gutter system, the catchwork system, and the bed system. The pane and gutter system is the best, and is admissible in all fields having a gentle rate of inclination. The land under this system is laid out, transversely between the open carriers that distribute the sewage, quite level; the sewage is brought to the head of the field in an open or covered main carrier running transversely across it, or in the direction of its least fall; the carriers for distributing the sewage branch out from the main carriers and run down the field in the direction of its greatest fall; the sewage is distributed over the intervening space between the distributing carriers by means of stops or sluices (see Fig. 1) being placed in the carriers, which dam back the sewage and make it flow right and left over the ground in a uniform stream.

Fig. 1.



The sewage passes from the main carriers into the secondary carriers at A (Fig. 2), which being dammed up at certain points are caused to overflow, the surplus water being carried away by the

Fig. 2.

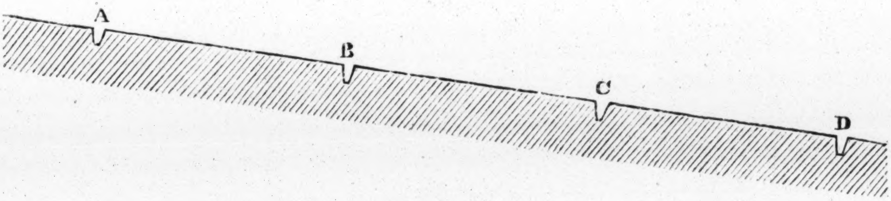


Pane and Gutter.

discharging drains B. A fair slope for this plan is from 1 in 100 to 1 in 120, or thereabouts.

The catchwork system is suitable in all cases where the ground has a rapid rate of inclination, as, for instance, on the side of a hill. It consists of a series of carriers one above another, as illustrated in Fig. 3. The sewage, flowing into the first and highest carrier, falls over the intervening land between it and the next lower carrier, which then takes up the water to distribute it in the same way on the land below it, and so in turn the process goes on till the bottom of the field is reached.

FIG. 3.



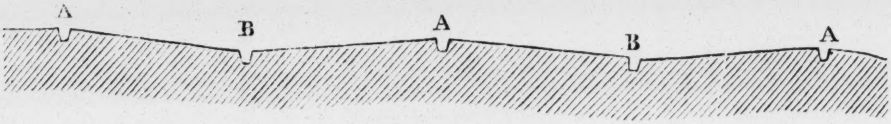
Catchwork.

The sewage is first received at A, and flows over the ground to B, thence to C, and it is finally conveyed away by the trough or carrier D. The carriers in this case may be cut at a distance from each other of from 35 to 40 feet. As to the slope itself, 1 in 12 would be found a good limit, although 1 in 4 or 5 has not been considered too steep.

The bed system is well adapted for level lands, or where there is but a slight fall. On this plan the land is laid out in a series of ridges and furrows; the sewage is admitted into carriers which run along the summit of each ridge, and falls over the incline into the furrow below. This will be readily understood from the annexed plan and description, Fig. 4.

A represents the ridge carriers which receive the sewage from the main carriers, running at right angles to them at the head of the field, and B shows the carriers in the furrows which are connected with the discharging drains. The sides of the slopes are carefully levelled to an inclination of about 1 in 120, and the ridges may be placed at an average distance of from 30 to 80 feet apart, according to the crop put into the ground.

FIG. 4.



Ridge and Furrow.

4. *Total Submersion.*—The method of carrying out this system is by raising a bank round the field to be irrigated, and then turning the water into it, where it is left until absorbed or evaporated, being from time to time replenished as may be necessary. It is extensively carried out in Piedmont and Lombardy in the cultivation of rice, and, unlike any other, it is the only system of irrigation that is considered likely to affect the health of the inhabitants in the immediate neighbourhood of its operation, its special drawback being that it converts every field where it is practised into a swamp of the worst possible description.

In conclusion, we may give the following short particulars regarding the selection of crops to be cultivated by sewage; on this point, however, more experience is required, as, owing to the greater facility by which it can be applied to grass, but few experiments have been made for its use with other crops. Fast growing, succulent grasses appear to be the favourite crops, and especially Italian rye-grass, of which crops varying from 30 to 50 tons to the acre may be obtained annually; and on one occasion as much as 61 tons were obtained in the year at the Lodge Farm, Barking. At Rugby some experiments have been made in the growth of oats, and the results reported to be of a most satisfactory nature. At Barking a couple of roods of land were ploughed up, irrigated with sewage, and sown with wheat; whilst a similar quantity of land, not irrigated, was also sown. The yield of the sewaged land was exactly 1½ time that of the land which was not so treated. Mangold wurzel has been grown with excellent results at Chelmsford, and at Barking the average return has been 50 tons per acre, just double that grown upon unsewaged soil. Winter greens, lucerne, beet, flax, celery, and cabbages have all been grown upon the farm at Barking, and have produced returns beyond all expectation, the onion being the only plant that evinced any repugnance at being treated with sewage.

Experience has now shown us that town sewage is not a refuse, and that allowing it to fall into the nearest rivers, or into the sea, is nothing more nor less than wilful waste, to such an extent as to amount to a national loss, to say nothing of the consequent diminution of food which ensues by the destruction of fish. Few towns are so situated as not to be able to dispose of a portion, at least, if not the whole of their sewage upon adjoining lands, and where this is the case no more economical plan for getting rid of it has yet been devised. Where such accommodation is wanting it may be found necessary to have recourse to some one or other of the artificial means of deodorization to which we have already referred; for although attempts to extract, by this means, a really valuable solid manure have hitherto proved unsuccessful, it would be unreasonable to draw the conclusion that means will not, sooner or later, be discovered whereby all the fertilizing properties of town sewage may be separated from the water, and made available for disposal in the shape of solid manure.

The following is a list of the works referred to in the foregoing article:—

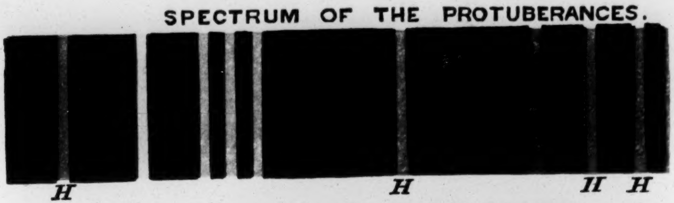
1. *Reports of the Commission appointed to inquire into the best mode of distributing the Sewage of Towns, and applying it to beneficial and profitable uses, dated March,* 1858, *August,* 1861, *and March,* 1865. Printed by Parliament.
2. *Reports of the Commissioners appointed to inquire into the best means of preventing the Pollution of Rivers, dated March,* 1866, *May and August,* 1867. Printed by Parliament.
3. *Lectures on Drainage, Sewage Irrigation, Water-supply, and Water-works, delivered at the Royal Engineer Establishment, Chatham, during the Autumn Session of* 1867. By Baldwin Latham, C.E.
4. *The Sewage Question.* By Frederick Charles Krepp. London: Longmans, Green, & Co., 1867.
5. *The Purification and Utilization of Sewage.* By Baldwin Latham, C.E. London: E. and F. N. Spon, 48, Charing Cross, 1867.
6. *Sewage, and its general Application to Grass, Cereal, and Root Crops.* By Thomas Cargill, C.E., &c. Robertson, Brooman, and Co., 166, Fleet Street, London, 1869.
7. *A Short Account of the Modes of Sewage Disposal in some of the Chief Towns in England.* By Capt. T. F. Dowden, R.E., 1869.
8. *Report on the Treatment and Utilization of Sewage by Commission appointed by the British Association,* 1869.

III. THE TOTAL SOLAR ECLIPSE OF AUGUST LAST.

By William Crookes, F.R.S., &c.

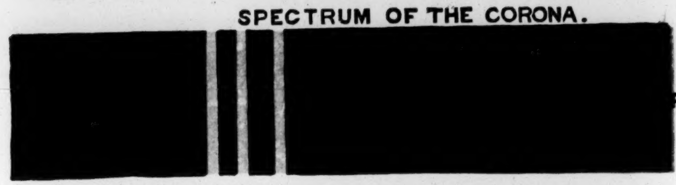
The important observations which were made last year with the spectroscope, polariscope, and photographic camera caused the total solar eclipse which took place on the 7th of August, and was visible over the greater part of North America, to be regarded with more than ordinary interest, as it was anticipated that the few minutes' opportunity then afforded would enable several points left doubtful last year to be satisfactorily cleared up.

SPECTRUM OF THE PROTUBERANCES.



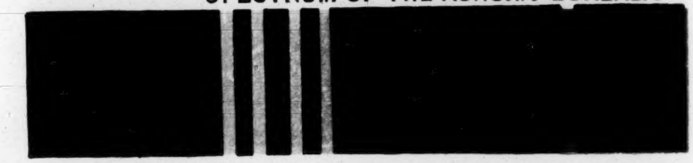
PROF^{R} YOUNG.

SPECTRUM OF THE CORONA.

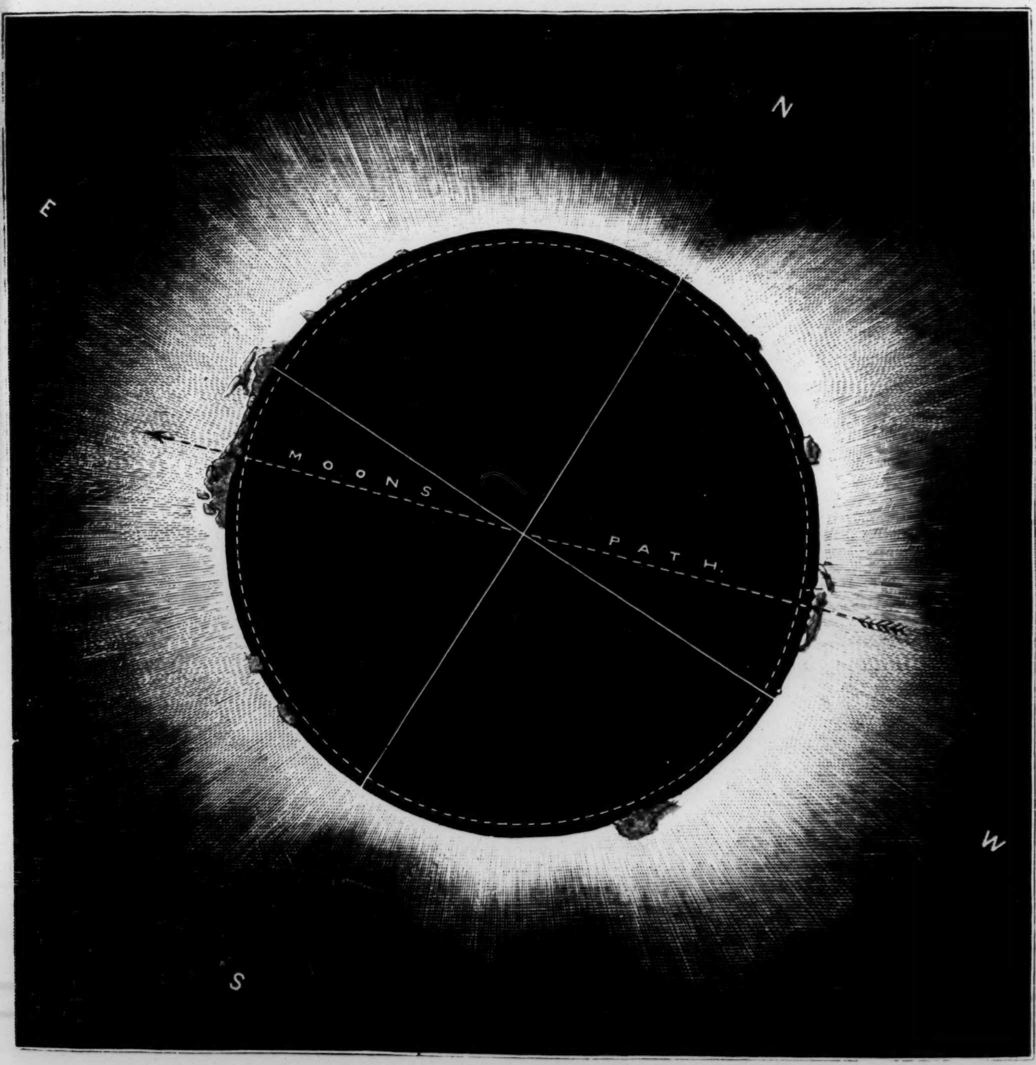


PROF^{R}. YOUNG.

SPECTRUM OF THE AURORA BOREALIS



M^{R} WINLOCK.



THE TOTAL SOLAR ECLIPSE OF 1869.

Commencing at noon in Alaska, the line of totality ran through British America, passing through the south-west corner of Minnesota diagonally through Iowa, crossing the Mississippi near Burlington, thence through Illinois, West Virginia, and North Carolina, and entering the Atlantic Ocean on the North Carolina coast, near Beaufort. The path of the eclipse through the more inhabited parts of the continent literally bristled with telescopes; the whole line being converted into one vast observatory. Although the duration of totality was less than in India last year, the circumstances were more favourable for observation, the heat being less and the position of the sun more convenient for observation, instead of being almost vertical. The principal points which had to be observed were the nature of the protuberances, examined with the spectroscope and recorded photographically; the nature of the corona; and the detection, if possible, of any intra-Mercurial planet. As might be expected from the easy accessibility of the entire line of totality, this eclipse has been most thoroughly observed by numerous parties, the report of whose work will in due time be presented to the scientific world.

The most important observations were those recorded by the Iowa expedition, towards the expenses of which 5000 dollars had been voted by Congress. The writer has to thank his friend, Dr. Henry Morton, Professor of Chemistry in the University of Pennsylvania, who had the superintendence of this expedition, for full details of the results obtained, together with some exquisite photographs of the phenomena of totality, &c. These pictures show, in the first place, very fine definition in the telescope employed, as the roughness or mountainous character of the moon's edge is clearly given in the pictures of partial phase, as well as the sun-spots and surrounding faculæ.

The telescopes which were available for the purpose were two fine Munich Equatorials, of 6 inches aperture, with clockwork, and also an excellent Dolland, of 4 inches aperture, equatorially mounted, but without clockwork. It was concluded that on account of the risk of local clouds it would be desirable to take all these instruments, and distribute them over some distance on or near the central line, and it was also considered that at least five skilled operators would be necessary to each instrument. The next important point was the choice of the party, and it was soon found that an excellent selection might be had from among those whose position or engagements would allow them to volunteer without other compensation than the moral one contingent on success; and after a few changes, rendered necessary by sickness or other inevitable cause, the party as finally constituted consisted, besides Professor Morton, of Professor A. M. Mayer, Ph.D.; Professor C. F. Himes, Ph.D.; Messrs. J. Zentmayer, O. H. Willard,

E. L. Wilson, H. C. Phillips, E. Moelling, J. C. Browne, W. J. Baker, James Cremer, H. W. Clifford, O. H. Kendall, J. Mahoney, and W. V. Ranger.

It was a question of some moment to decide whether, for obtaining the photographic records, they should follow the plan adopted by the French and German expeditions of last year, and take the photograph in the principal focus of the object-glass, thus securing great intensity of light in a small image, or follow the method employed by Dr. De la Rue in 1860, when he used an ordinary Huygenian eye-piece so placed as to produce an enlarged image of the first image from the object-glass. It was found by experiment that with a clear sun it was necessary to reduce the aperture of the telescope (which was 4 inches, and 50 inches focus) to $1\frac{1}{2}$ inch, and to use a diaphragm slide of $\frac{1}{40}$th inch aperture, in order to get a proper exposure when the solar image was enlarged from ·6 inch (its diameter at the principal focus of the objective) to $2\frac{1}{2}$ inches on the ground glass. The same size of aperture was adopted for the larger instruments during the partial phases, the entire aperture, in all cases, of course being used during totality.

The work of designing and constructing these lenses, and also the different attachments to the cameras for securing exposures of various degrees of rapidity, from a very small fraction of a second to any desired length, was placed in the hands of Mr. Joseph Zentmayer, whose extended scientific attainments, combined with unrivalled skill in the construction of optical instruments, peculiarly fitted him for such a task.

As the operation of the eye-piece, when employed to produce an image on the screen or ground glass of a camera, is essentially different from that which it performs in its usual office, it was judged best by Mr. Zentmayer to make some alterations in its form. Thus, in the first place, since in the present case the "eye-lens" of the eye-piece undoubtedly makes a secondary image of the primary image formed within the eye-piece by the combined action of the objective and the field-lens of the eye-piece, it is clearly desirable to make this lens of a longer focus than usual, so that its errors may be of less account. It was also essential to give the new eye-piece a wide angle, so as to secure a sufficient field not only for the solar disc, but also for the corona.

While therefore the ratio of focal lengths in the two lenses of the ordinary eye-piece is usually 1:3, it was in this case as 1:2. While the distance between the lenses is usually the sum of their focal lengths divided by 2, it was here made equal to the sum of the focal lengths divided by 2, plus ·24 inch. This was to give space for the introduction of the reticule of spider lines, which would otherwise have been brought too near the field-lens, and also to keep this lens beyond the conjugate focus of the eye-lens, as otherwise particles of dust on the former would have been too faithfully portrayed by the latter.

The elements actually adopted were as follows:—

	Ft.	In.
Focal length of objective	8	6
Radius of field-lens	0	1·375
" eye-lens	0	0·687
Focus of field-lens	0	2·6
Diameter of field-lens (= R)	0	1·375
Focus of eye-lens	0	1·3
Diameter of eye-lens (= R)	0	0·687
Distance between lenses, 1·95 + 0·25	0	2·2
Equivalent	0	1·75
Distance of reticule from eye-lens for 5-in. distance of ground glass	0	1·62

When the instruments were boxed and packed, it was found that, with the various photographic appliances, they made no less than five furniture-car loads of material.

In arranging the division of the party into three sections, with the three telescopes, so that they might be distributed along the line of totality, and thus diminish the chance of universal extinction by local clouds, Professor Morton was chiefly guided by the desire of securing in each section such a diversity of special ability as might make each self-dependent and complete; also, to leave nothing undone to secure content and harmony of feeling. He assigned to himself the University telescope, which being of smaller size and without clockwork movement, could not be expected to do as good work as the others: though should *they* by chance be overclouded, *its* result would be invaluable.

The High School telescope, 6-inch aperture, 9 feet focal length, was under the charge of Professor A. M. Mayer, Ph.D., and Mr. O. H. Kendall. It was stationed at Burlington, 40° 48′ 17″ N., 0 h. 56 m. 13 s. West of Washington. By measurements of the photographs taken by this party, Professor Mayer has shown a change of shape in one of the larger spots during the eclipse, amounting to a motion of 2000 miles, in its edges.

The Gettysburg telescope, 6-inch aperture, 8½ feet focal length, was in charge of Professor C. F. Himes, Mr. J. Zentmayer, and Mr. E. Moelling. This was stationed at Ottumwa, about 75 miles nearly west of Burlington.

With the University telescopes were Mr. E. L. Wilson and Professor Morton. This section was placed at Mount Pleasant, between the other stations.

It is almost needless to say that all officials connected with the railways acted with the greatest liberality in transporting the apparatus and observers to the selected sites.

The various parties having reached their destinations, arrangements were at once made to get the instruments into position. In the case of the Burlington party, all went smoothly, and the dark weather alone prevented final adjustment until the night of the 6th, or morning of the 7th, when this was secured by Professor Mayer, who sat up all night for the purpose.

With the Ottumwa instrument it was, however, found that the clockwork had become seriously deranged in carriage, so that Mr. Zentmayer was obliged to take it entirely apart and refit it. The final adjustment was only given to this instrument during the morning of the 7th by Mr. Zentmayer, who had watched all night, vainly, for a star.

The telescope at Mount Pleasant having no clockwork, and being otherwise unfit for any fine adjustment, required no arrangement except what could be given during the morning of the 7th.

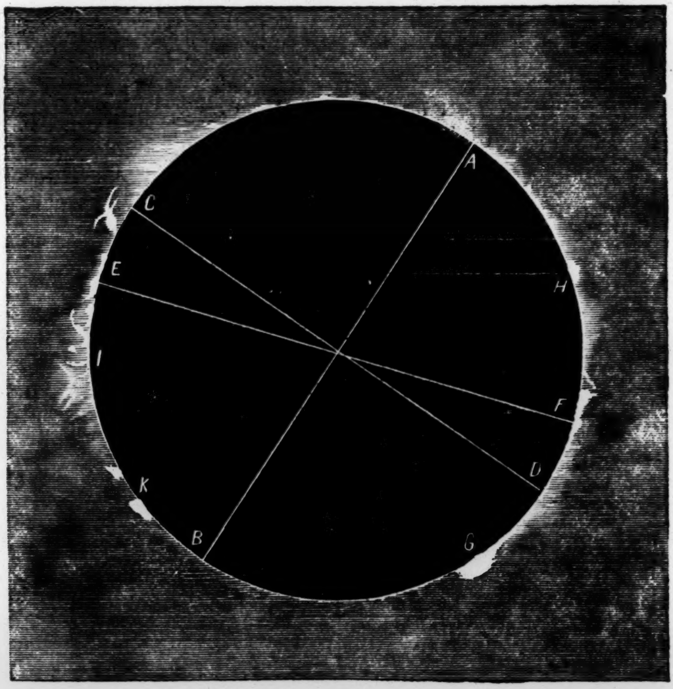
The weather on the eventful day of the eclipse was at all stations perfect, thus rendering needless the policy of distribution, and no less than 116 negatives were taken, including 13 during totality, showing a large number of prominences, some massive and others delicate as well as radiant brushes of a softer light, such as have been before seen, but never as yet photographed. By another of the sections of this large party, beside similar pictures to the above, one was obtained showing the curious phenomena known as Baily's beads, being simply the last glimpse of the sun's edge cut by the peaks of lunar mountains into irregular spots. The time of exposure determined by Professor Mayer for the partial-phase pictures was the $\frac{1}{500}$th of a second. Those taken during totality were exposed from five to sixteen seconds.

The general character of the prominences will be seen by the coloured illustration, which has been excellently copied from the original photographs and micrometric measurements forwarded to us by Professor Morton. The dotted circle inside the circumference of the moon, shows the relative diameter and position of the sun at the middle of the total eclipse. The accompanying woodcut may be regarded as a key to the coloured picture, and will serve to facilitate the following description of the phenomena:—

The line A B represents the direction of a parallel of declination. C D a declination circle. F E is the moon's path from first contact at F. The prominences are here all shown at once; although, of course, those on the sun's eastern limb alone were seen at first, those on the west side only at the end of the totality. Proceeding from the north to the east, we first meet with a small prominence having the position angle of about 56° 30′; it is of the shape of a rice grain, with its base but slightly below the circumference of the moon. In breadth it is 2° 50′, and in height 22″; as 1′ on the circumference of the sun equals 124 miles, and 1″ of arc of the sun's distance on August 7th subtends 449 miles, it follows that its actual dimensions are 21,000 miles long and 9900 miles high.

The next protuberance lies imbedded in the moon's border, and has in form the appearance of a short, deeply-articulated worm; its mean position is 69° 17′; its length 46,700 miles, and its greatest height 9900; between that protuberance and the point C on the woodcut, are two flames in the midst of the glow previously described. Midway the diffused light rises to an elevation of 60,500 miles. We now come to a curiously-formed protuberance. Some have compared it to an ear of corn, but in the photographs it appears like an eagle with outspread wings resting on the trunk of a tree which leans towards the north. On one plate where the tree-stump is cut off by the advancing moon, the resemblance to an eagle on the wing is perfect. The form of this object indicates instability, and impresses one with the idea that it is a great travelling whirl of flame, the direction of whose rotation—as indicated by the position of the wings and the projection of one on the other—is retrograde, or in the same direction as the motion of the hands of a watch. Dr. Mayer, chief of the Burlington Section of the Philadelphia Photographic Expedition, has examined, with care, the successive photographs of it, and he says that although at first he thought that the last impression differed from those preceding in that the wings had become longer and more in a line with each other, yet on subsequent examination he could not really decide that a perceptible motion had taken place during the time of totality. The height of this object is 36,700 miles, and the spread of the

FIG. 1.

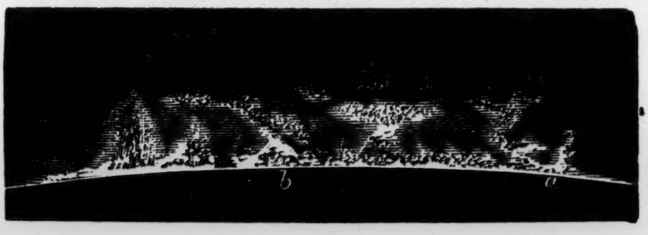


wings 70,800 miles. The next protuberance extends to between E and I on the woodcut; it is of very irregular outline, and shows portions of its substance detached from the general mass and floating freely above it. The most elevated and bright of these detached flames floats at a height of at least 20,000 miles above the surface of the sun. Beyond I a white nebulous cloud rises to the elevation of 60,500 miles. Next follow two protuberances at K.

We now pass to the western limb of the sun, and meet with the remarkably large and massive protuberance at G on the woodcut. It is shaped like a bird's head, with the beak and under-side of the head resting on the limb of the moon. On a photograph taken at Ottumwa, Iowa, just before the sun came out, this protuberance had the exact appearance of an albatross head with the beak open, holding a rounded mass between the extremity of the jaws. The protuberance at F bears the most striking resemblance to a caterpillar. It extends through an angle of 11°, or 81,800 miles; its maximum elevation, which is at the head of the caterpillar, is 23,000 miles. Out of the head issued two horns; the one nearest the front being the higher of the two, and terminated with a knob or ball from which curves a broken line of light to the border of the moon. The next prominence at H has the shape of a grain of rice slightly constricted in the middle. Between H and A is another protuberance.

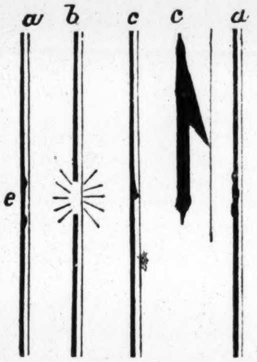
Professor Young, who examined these prominences during the totality, has continued his spectroscopic notes of the prominences since the eclipse, and on September the 13th he obtained a view from which the accompanying woodcut is taken. He describes it as a long, straggling range of protuberances—the sketch giving a very fair idea of the number, form, and arrangement of the immense cloudy mass. The points *a* and *b* were very bright.

Fig. 2.



On September 18th he noticed a remarkable phenomenon, which, although not bearing directly on the eclipse phenomena, is sufficiently rare to make it deserve recording in these pages. Whilst examining the spectrum of a large group of spots near the sun's western limb, his attention was drawn to a peculiar knobbiness of the F line (on the sun's disc, not at the edge), represented by the following cut *a*, at the point *e*. In a very few moments a brilliant spot replaced the knobs; not merely interrupting and

FIG. 3.



reversing the dark line, but blazing like a star near the horizon, only with blue instead of red light. It remained for about two minutes, disappearing, unfortunately, whilst the observer was examining the sun's image upon the graduated screen of the slit, in order to fix its position. It is not known, therefore, whether it disappeared instantaneously or gradually. *b* gives an idea of this appearance. On returning to the eye-piece, Professor Young saw what is represented at *c*. On the upper (more refrangible) edge of F there seemed to hang a little black moat, making a barb, whose point reached nearly to the faint iron line just above F. As given on Angström's atlas, the wave-length of F is 486·07, while that of the iron line referred to is 485·92 (the units being millionths of a millimètre). This shows an absolute change of 0·15 in the wave-length, or a fraction of its whole amount, represented by the decimal ·00030, and would indicate an advancing velocity of about 55·5 miles per second in the mass of hydrogen whose absorption produced this barbed displacement. The barb continued visible for about five minutes, gradually resolving itself into three small lumps, one on the upper and two on the lower line, Fig. 1, *d*. In about ten minutes more the F line resumed its usual appearance.

Whilst on the subject of the solar prominences it may not be out of place to refer to some observations by Professor F. Zöllner, who has succeeded in observing them without an eclipse with great sharpness and clearness. From the nature of the method the same protuberance was simultaneously observed in three different colours corresponding to the three homogeneous lines of its spectrum. There is, however, a material difference between the red and blue image on the one hand, and the yellow on the other. The latter is very intense only in close proximity to the edge of the sun's disc, and in this respect corresponds to the other images; while the more delicate details disappear at a greater distance. This difference does not seem to be caused by the greater brightness of the spectrum in that region, but appears to depend on one of the two following hypotheses for an explanation:—either that the rays which give rise to the yellow image emanate from a gas having a greater specific gravity than hydrogen, and therefore existing at a lower level, or that the greater intensities of temperature and pressure nearer the surface of the sun cause hydrogen to emit these rays.

Professor Zöllner's paper, which will appear in the next number of the journal of the Franklin Institute (for early proofs of which the writer has to thank Professor Morton, the editor), is illustrated with beautifully coloured drawings showing the rapid changes which sometimes occur in the forms of these prominences even in the course of a few hours. Observing one of the most remarkable formations, the Professor says, "I hardly believed my eyes when I noticed in it the tongue-like motion of a flame. This motion was slower, however, compared with the size of the flame than that of high towering flames at great conflagrations. The time required by such a wave in passing from the base to the apex was about two or three seconds."

In comparing the general impression of the protuberances with terrestrial phenomena, the author states that the great majority remind him of the different forms of our clouds and fog. The cumulus type is completely developed in the cases here referred to. Other formations remind us of masses of clouds and fogs floating closely over lowlands and seas, whose upper parts are driven and torn by currents of air, and which present the well-known ever-varying forms when viewed from the tops of high mountains.

Professor Zöllner hopes, by using larger prisms and a circular slit in the spectroscope, to be enabled to observe simultaneously all the protuberances on the edge of the sun, in the different parts of the spectrum, just as in a total solar eclipse of long duration.

Returning to the August eclipse, one of the most beautiful observations was on the first contact by means of the spectroscope. Professor Young has been giving much attention to this subject, and had fitted up a very efficient instrument for the purpose. The instrument consisted of a spectroscope with five prisms of 45° each, having faces 2¼ by 3¼ inches; the collimator and telescope had apertures of 2¼ inches, with a focal length of 17. These were connected with a comet-seeker of 4 inches aperture and 30 inches focus, used with an eye-piece, and giving an image of the sun 2½ inches in diameter on the slit of the spectroscope. A graduated screen at the slit determined positions of points on the sun's limb, and a wire micrometer measured the positions of spectrum lines. The whole was mounted equatorially with slow-motion screws. During the eclipse he was stationed at Burlington, Iowa, and shortly before the first contact was due, he found that there was a solar prominence located at the spot where first contact must occur (see F in cut on page 33). He therefore fixed his spectroscope with the slit radial to the solar edge at the point, so getting a prominent spectrum whose width was determined by the height of the prominence. Closely watching this, he presently found that it began to narrow steadily, and at the instant that it became a mere line and disappeared he recorded first contact. The moon's approach was perceived full 30″ before its actual appulse; the observation was perfectly easy, and the time determined is certainly to be relied on within half a second, and probably much less. The presence of a prominence at the point of contact is not essential to the success of the method, as there is everywhere on the sun's limb sufficient depth of chromosphere to answer the purpose. From the first photograph showing contact made by the Philadelphia party at the same place, Professor A. M. Mayer, who had charge of that division, calculated the time of actual first contact, and found that it came within two-tenths of a second of the record made by Professor Young.

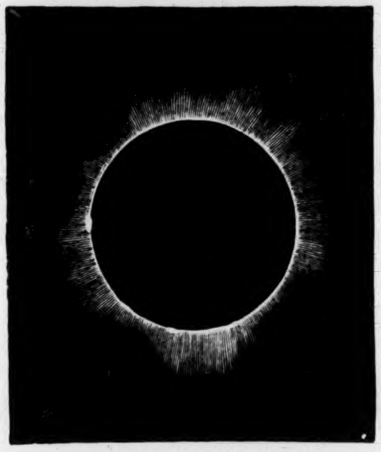
Professor Young proposes to apply the spectroscope in this manner to observations both of the external and internal contacts at the next transit of Venus.

The partial-phase pictures show the various sun-spots visible at the time (about six in number) with admirable definition, the larger ones being surrounded by a marked fringe of faculæ. They all show a beautiful gradation of shade from the border of the sun inwards. This shading of the source of light is due to the absorption of the peripheral rays which necessarily pass through a greater thickness of the dense solar atmosphere than those which emanate from the central portion of the disc; on a more searching examination of the relative intensities of light of different portions of the solar disc, there may be observed on all of these photographs, close to the limb of the advancing or retreating moon, a bright glow like that of early dawn, which extends from the moon to a distance of about 15″. Unless this glow can be accounted for in node and in measure by diffraction, it would appear as if it were due to a lunar atmosphere, although Dr. Mayer, in suggesting this explanation, confesses that he cannot understand how an atmosphere capable of producing such marked effects when projected against the intensely lighted disc of the sun, should have no appreciable refractive effect on small stars when occulted by the moon. We should be more inclined to account for this glow as being the effect of specular reflexion from the surface of the moon grazed by the sun's rays.

A party under Professor Pierce devoted themselves exclusively to the recording of that strange phenomenon, the corona. To secure any impression from this object, which, notwithstanding its apparent brightness, is remarkably deficient in photographic power, it was necessary to make a very small image and to give a very long exposure.

The telescope was therefore arranged to produce an image in its principal focus simply, and during the totality an exposure of forty seconds was given. By this means a picture was obtained of which the cut on the next page is a very careful copy. From the long exposure, the motion of the moon, and probably also of the light in the corona, there is little sharpness of definition, and the prominences only appear as bright spots. The general shape of the corona is, however, very well given, and the curious appearance of curvature, in some parts, is very manifest. Professor Himes, who was at Ottumwa, describes the corona as approaching much more nearly in regularity the four-rayed form generally given, and which had always seemed idealized or conventional. The S.W. ray was, however, unequally subdivided with the smaller part towards the north. The whole seemed of a fibrous, slightly curled or twisted character, somewhat like a cirrus cloud, and of silvery whiteness. The prominences, especially the large one a little to the left of south, seemed at the first instant of a dazzling white, but after his attention had been diverted for a few moments, it appeared of a brilliant decided rose colour bordering on crimson, and remained of this colour to the close. To Mr. Zentmayer, who was engaged at the camera and had used neither telescope nor screen, it appeared white, with a slightly roseate hue. To Mr. Moelling, under similar conditions, it appeared white throughout. Messrs. Brown and Baker, who had a short glimpse of it from the door of the dark room, rather incline to the opinion that it was white. Professor Pickering, who was at Mount Pleasant, Iowa, describes the corona as an irregular four-pointed star with, of course, a black centre. Two of the rays were nearly vertical and two horizontal, the left-hand one pointing somewhat downward, while between it and the lower ray was a fifth smaller point. The colour was pure white, very different from the full moon, but resembling a cumulus cloud. Its texture resembled the ragged edge of a thundercloud, or the crest of a wave torn by the wind. The striæ were not radial but spiral, as if the sun had been turned in such a way that the upper edge moved towards the east.

FIG. 4.



During the totality Professor Young gave special attention to observation of the corona with the spectroscope. He found that, in place of a subdued solar spectrum, which would have been anticipated from the reports of former observations, it yielded a spectrum of bright lines. These are represented in the coloured illustration, and below the spectrum of the corona is given a copy of the spectrum of an aurora borealis as observed by Professor Winlock on the evening of April 15th. From the close accordance between the coronal lines and three of the auroral lines, Professor Young considers it almost certain that the corona is simply an electric discharge, no doubt varying with great rapidity, as we see in the case of the aurora; in fact, that the solar corona is a permanent aurora. It is, however, right to state that in an article by

Mr. J. N. Lockyer in 'Nature,' for November 4th, he throws some doubt on this conclusion, and hesitates to regard the question as settled, were the new hypothesis less startling than it is.

The most complete series of spectroscopic observations were those taken of the prominences. During totality nine bright lines were observed by Professor Young in the spectrum of one of the protuberances, *viz.* C dazzling in brilliancy; 1017·5 (near D, the numbers refer to Kirchhoff's scale) very bright, but not equal to C; 1250 ± 20, very faint, position only estimated; 1350 ± 20, like preceding; 1474 (a little below E), conspicuous, but not more than half as bright as 1017·5; F next to C in brightness; 2602 ± 2, a little fainter than 1474, position determined by micrometrical reference to the next; 2796, a little below G; the well-known H γ line in brightness between 1017·5 and 1474; and finally *h*, or H δ, somewhat brighter than 1474. *b* it is supposed was not seen; on account of a mistake in carrying that portion of the spectrum through the field, there was no prominence on the slit. The lines marked H in the coloured illustration are hydrogen lines.

The opportunity which was afforded by the total obscuration of the sun's light was taken advantage of to search for planetary bodies between Mercury and the sun, but without success, although Mercury, Venus, Mars, Saturn, Regulus, and Arcturus were plainly visible. The horizon all around was lighted up by a sort of dim twilight for four or five degrees in breadth, and above this rim of light hung a leaden canopy, increasing in depth towards the zenith.

At the Ottumwa station a curious appearance was noticed by Mr. Zentmayer. During the time that the pictures of the partial phase were being taken at long intervals, the ground-glass plate was put in the camera to note any irregularities in the clock movement, should they occur. About twenty-five minutes before the totality, Mr. Zentmayer observed some bright objects on the ground-glass, crossing from one cusp to the other of the solar crescent. Each object occupied about two seconds in passing, and they all moved in right lines, nearly parallel, and in the same direction. These points were well defined, and conveyed to the mind of Mr. Zentmayer, who is accustomed to the use of the camera for photographic purposes, the strong impression of being images of objects, and not points of light merely. It is, moreover, certain that the objects, whatever they might be, must (in order to have produced such sharply-defined images on the ground-glass) have been several miles distant from the telescope, as even a point of light at a less distance would have produced an enlarged image, with a hazy border.

The most complete account of the photographic operations is recorded in the report to Professor Morton by Dr. Mayer, who was the chief of the Burlington party. They arrived at their destination on August 4th, and up to the morning of the 7th they were occupied in putting together the base and frame of the telescope, mounting the bed-plate, the polar and declination axis and circles, the cradle holding the telescope, fitting-in the tube and optical part, adjusting the verniers and bringing the instrument into altitude and azimuth adjustment. The whole of Friday, August 6th, there was a driving rain, an east wind, and a dull murky atmosphere, foreboding the worst results on the morrow—after having spent previous weeks in preparation, and having travelled over a thousand miles, in the hope of carrying back with them permanent photographic records of the long-thought-of eclipse.

As they retired to rest there appeared signs of the clouds breaking. They had barely fallen asleep when the clerk, according to previous arrangement, woke them with the agreeable news that there were plenty of stars. They were soon dressed, and were charmed by the sight of a cloudless sky; and Professor Coffin, Drs. Gould and Mayer were up all night putting their own special instruments in adjustment. When all was finished, the sun was rising, and the air as pure and serene as one could wish. On Saturday morning the chronograph was mounted, and electric wires were led to the camera, to Professor Young's spectroscope, and to the station of Dr. Gould outside the building. The two threads of the reticule of the camera were placed one parallel and the other at right angles to the celestial equator, and experiments were now begun by Mr. Willard to ascertain the chemical focus. This was obtained after the tube had been following the sun for an hour or more, and after the focus was fixed the clockwork was kept going, so that no change in focus should supervene from a change in temperature in the lenses and tube. The clockwork adjustment had been regulated with such accuracy that it drove the telescope so that a star would remain closely bisected for twenty minutes. By 3 P.M. all was in readiness, and each one at his allotted post of duty, ready for work.

The image of the sun was 2·04 inches in diameter, and was taken on a $4\frac{1}{4} \times 5\frac{1}{2}$ inch plate. Mr. Zentmayer had so constructed the camera eye-piece, that the image of a reticule of two spider-threads at right angles to each other was formed on the plate with the image of the sun, and these threads were so mounted that they could be adjusted respectively parallel and at right angles to the celestial equator, and thus fix on the photographs the positions of the sun and moon, and give the position angles of points on the surface and periphery of the sun.

The tube carrying the camera lenses screwed into a plate in which, immediately in front of the anterior lens, was a guide, in which a thin plate having a horizontal slot of ·0224 inch in width was caused to descend by the action of a spring. This was used for the partial phases. During totality the full aperture of the object-glass was employed, and a slide plate was used, having a circular opening which allowed the full beam to pass. This plate had two falls instead of one. On setting the plate free by the top trigger it fell, and the collodion plate was exposed to the entire beam; after the desired exposure a lower trigger was relieved, and the plate made a second fall, and the lens being covered by the top of the plate, the exposure ceased. These triggers were connected with a Morse register having a paper fillet running through it; at every second the clock for an instant opened the electric circuit, and there was a very short break made in the line marked by the pen on the fillet; thus the seconds of *time* were stepped off in *space* on the paper ribbon. The triggers were so connected with this chronograph that an additional break was made during the time the photographic plate was being exposed. By measuring this break on the paper ribbon and comparing its length with the length of the second in which it occurs, the exact fraction of the second during which the plate was exposed will be given.

Dr. Mayer arranged for his own duty to keep the telescope in adjustment, and to manipulate the apparatus of exposure and chronographic registration, while Mr. Willard placed the plate in the camera and gave the several times of exposure he desired during totality. Mr. Phillips coated the plates and handed them to Mr. Montford, who carried them to Mr. Willard, and thence, after exposure, to Mr. Mahoney, who developed them, assisted by Mr. Leisenring.

The wall of the dark room adjoining where the telescope stood was fitted with two dark valves, or dumb waiters, by which the plate-holders could be passed in and out without the admission of light or the necessity of any of the operators moving from their places. Seven negative baths were used, standing in a trough of water to keep them cool, four plate-holders, and a large wooden trough with grooved sides, similar to a negative-rack; this was filled with a weak solution of hyposulphite of soda. In the dark room the first operator's duty was to coat plates and put them into the baths; the second took them out, put them into the plate-holders, and passed them out of the room by means of one of the dumb waiters. After exposure, the holders were returned to the dark room by the second dumb waiter, when the third operator took the plate from the holder, developed, washed, and then dropped it into one of the grooves in the large fixing trough. There the plates remained slowly fixing till after the eclipse was over, when they were taken out in the same order in which they were put in, washed, and numbered with a diamond.

At the telescope Mr. Rock was detailed to attend to the very important duty of calling out the seconds of the chronograph-fillet;

Mr. Kendall called out the minutes at each 60-seconds call of Mr. Rock, and wrote it on the fillet. He also had charge of the chronograph, and started it when Dr. Mayer called "clock," while, at the same signal, Mr. Rock began the registration of seconds.

Dr. Mayer had laid out the following programme of work:—First to take in rapid succession, beginning 10 seconds before the computed time of first contact, a series of five photographs. Secondly, one just before second contact, one just after second contact, as many as possible during totality, one just before the end of totality, and another just after the sun reappeared. Thirdly, to take again a series in rapid succession about the end of the eclipse. Fourthly, during partial phase, to take a picture every four or five minutes.

When the chronometer marked 12 h. 48 m., Mr. Rock began to count and register the times on the fillet. Every one was at his post, the lanterns lighted, and nothing could be heard but the count and tap of the chronograph. At 12 h. 49 m. 45 s. the first photograph was taken, and following at intervals of from 10 to 12 seconds five perfect pictures were secured. The contact is first visible on the third. Photographs were now leisurely taken at intervals of about four minutes, until twelve plates in all were taken.

About five minutes before totality, Mr. Willard removed the diaphragm of two inches aperture, which was used during partial phase, and exposed the full aperture of the object-glass, whilst Dr. Mayer changed the slide with ·0224-inch slot for the one which admitted the whole beam at once on the plate in the camera.

The order was given to prepare the plates. The first plate was taken at 13 h. 51 m. 39·15 s., or 7 seconds before the time of second contact as observed by Professor Coffin. The slide was soon reset for another exposure, and as Mr. Willard desired the first plate of totality to be exposed five seconds, Dr. Mayer kept on counting zero, zero, zero, with the taps of the chronograph, until striking the upper trigger at zero, he counted one, two, three, four, five, when the lower trigger was struck and the plate removed.

Counting the first plate, taken seven seconds before second contact, six photographs were taken in 2 m. 3 s. After the sixth was removed there still remained 50 s. of total phase. There was a delay in the plate. The observer grew impatient; he called plate! plate!! but, alas, it was found impossible to manipulate more than six plates in two minutes and three seconds. The store had been used up too rapidly, and so they did not succeed in getting an impression just before the sun came forth. The next plate was taken 29·2 seconds after third contact, and is a valuable photograph of a thin crescent, with the cusps sharply cut.

Dr. Mayer describes the appearances during totality in the following words:—"About 15 minutes before totality it became so cool that I was obliged to put on my coat. A minute or two before totality, the sky grew ashen, or rather leaden in hue, and as, with face turned towards the sun, I kept the count from the chronometer for the first exposure, Venus and Mercury came out shining beautifully on a ground of bluish grey. I thought I saw a flashing, twirling motion in the corona, or in the last rays of the sun; but of this I will not be positive, for my attention was not, at the time, specially directed to minute observation. Moths and insects in profusion passed between me and the sun, while a flock of birds with troubled irregular flight seemed seeking cover from the unnatural gloom which surrounded them. A low moaning wind now sprang up, and the whole atmosphere seemed filled with a lead-coloured vapour, and I experienced an indescribable feeling of oppression when I tapped the trigger, and, from that instant until the sun appeared, I had nothing but an *instrumental* consciousness, for I was nothing but part of the telescope, and all my being was in the work which I had to perform. I reset the slide, made circuit, exposed, and so on over again, until the six photographs were taken, when I had the mortification to find 50 seconds of totality, and that no plate could possibly be obtained; we were *too* quick."

Photographs were now taken leisurely at intervals of about four minutes until 14 h. 47 m. 48·4 s., when the first of the series for the end of the eclipse was secured; this was followed by four others at intervals of about a quarter of a minute. The work was finished in a few seconds, the eclipse of August 7th, 1869, was of the past, but its history had been faithfully recorded in forty-one perfect photographs.

IV. INSTRUCTION IN SCIENCE FOR WOMEN.

It would seem hardly necessary, in this day of awakening common sense, to put the questions, Is it necessary to impart scientific instruction to the female sex? and what kind of information should be conveyed to women?

As to the first inquiry, there are, no doubt, still a great many old women of both sexes who consider that if a girl be taught to read, write, and know sufficient of arithmetic to enable her to detect errors in her butcher's or washerwoman's book, any further intellectual instruction is superfluous, and unfits her for household duties. But it being once admitted that such a proposition could only emanate from old womanhood, in the disrespectful sense of the term, and that scientific instruction would be of the greatest benefit to those whom we shall still delight to call the fair sex—not the less fair because more intellectual—we need have no difficulty in determining what should be taught to them, and in what manner the instruction should be imparted.

As a mere education of the intellect, there is no reason for making any difference between the method of conveying scientific information to male and female students. It may be said that some branches of physiology are not fit subjects for young girls—neither are they for young boys;—and with more propriety it may be urged that the refinement of woman's nature would be shocked or deteriorated by the receipt of certain information from men, even when the pupils have arrived at the age of maturity. But this is only another argument in favour of every effort being made, without loss of time, to train women to be the teachers of their own sex in the mysteries of human anatomy and physiology.

To deny the necessity of imparting this particular kind of instruction at all is simply absurd; for whilst women may make good wives and mothers, without possessing any knowledge of Botany, Electricity, Astronomy, or Chemistry, they cannot possibly be fitted to fill their accustomed sphere without a fair amount of information concerning the laws which govern their own corporeal frame in health and disease, and somewhat at least of the constitution of the other sex.

That assertion will no doubt be met by the stock argument, "How have our fathers and mothers and our ancestors managed without such knowledge?" or, "What are doctors for?" They have managed to lose one, or two, or three children in succession from the effects of disease; or perhaps it would be more correct to say, from ignorance of the meaning of directions left by their medical adviser, when by a little intelligent care all would have survived. It is not the doctor who saves the patient's life; it is he who directs how it is to be saved; and however able the physician may be, the fate of the patient, in five cases out of six, depends mainly upon the intelligent construction and fulfilment of his wishes by the nurse. Of what use, at a critical period of disease, is any amount of information concerning the latest novel or opera? Will the most artistic display of chignon, or the widest acquaintance with the mysteries of fashion, avail to protract the hours of a beloved husband, or the moments of a child's life, whilst it sinks under an exhausting disease?

It would be a waste of time to discuss here the best system of imparting general scientific instruction to women, as distinguished from men; but it may be interesting to dwell for a few moments upon the method which is being adopted at South Kensington—not because it appears to be efficient in the case of women only, but because, being advantageous in their case, it would be beneficial wherever minds untutored in science are to be appealed to, and the effort made to convey scientific information. And having briefly considered that phase of the subject, we will cursorily refer to the special instruction in those branches of science which would seem the best adapted to favour, materially and mentally, the progress of females as working women.

The series of lectures at South Kensington, which, it should be premised, is by no means the initiation of the movement, consists of three courses—one by Professor Huxley, on what he calls Physiography; a second by Professor Guthrie, of Jermyn Street, on Elementary Physics and Chemistry; and a third by Professor Oliver, of Kew, on Biology. The last named is, however, chiefly, if not entirely, confined to Botany and Vegetable Physiology. Of Professor Huxley's lectures we will speak first, and to illustrate his method of imparting tuition, we will endeavour to describe his introductory lecture.

"Physiography" is explained to mean "a description and rudimentary analysis of those obvious natural facts and events which are commonly treated of under the head of elementary physical geography;" and in his introductory lecture Professor Huxley described the changes which are taking place in a river basin, as illustrated by the ebb and flow of the tide in the Thames, the supply which it receives from its tributaries, from the condensation of watery vapour in the atmosphere, and from other sources.

The information which he desires to convey seems of the most commonplace character, consisting of an account of the form of the Thames Basin; the appearance of the river as seen from a balloon; the relative extent of the fresh and salt water currents; the bulk of fresh water which flows down to the sea, and never returns; and so forth. But it is more than probable that not six of the ladies present (for they were all ladies in the conventional sense of the term who constituted his audience) possessed even a superficial acquaintance with the phenomena in question, and perhaps not one would have been able to answer correctly the questions which might have been put from his programme. Nor is this anything to their discredit. How many of our readers are there who could tell us what number of cubic feet "more water runs down than runs up beneath London Bridge every day?" or where "Thames Head is?" or "How far it is from London Bridge, and how high it is above the Thames at that bridge?"

The lecturer managed, however, not only to instil this information into his hearers' minds, with the aid of a chart and black-board; but with his bottle of cold water, which served at the same time to refresh his body and illustrate his subject, he explained with great clearness the laws and phenomena of radiation, heat, congelation, &c., and some of the leading principles of meteorology. His address may be said to have been an ideal picture of the cycle of changes which are constantly going on between earth, sea, and air, in so far as the transfer of water is concerned. In his subsequent lectures he described (or intended to describe—for this article was written shortly after his opening lecture) similar phases in the circulation of solid matter (earth), and the transformations of living matter (plants and animals).

Turning for a moment to the lectures of Professor Guthrie, on Physics and Chemistry, it may be asked of what use instruction in chemistry can be without laboratory practice; and although it is probable that the ladies will see none of that at South Kensington, and indeed that only the most rudimentary instruction in chemistry can be imparted in a course such as Professor Guthrie will give; yet when we look at what is being done elsewhere, we shall find not only a supply, but an active demand for laboratory instruction.

Mr. Mylne, the Honorary Secretary of the Ladies' Educational Association, which carries on its operations in connection with University College, has sent us a programme of the scientific lectures in course of delivery at the College in Gower Street, and he informs us that Professor Williamson not only gives instruction in theoretical chemistry, which we find from the prospectus to embrace the organic as well as the inorganic section, but that he has instituted laboratory practice, several ladies having expressed a wish for this mode of instruction. In connection with this series of lectures it may be further added that Professor G. C. Foster is delivering a course on Dynamics and Heat; and Professor Hirst one on Geometry. There are lectures on the living and dead languages and literature, but with those we have no concern here.

Professor Oliver, at South Kensington, proposes to illustrate the laws of biology, as we have already stated, chiefly by a reference to the realm of plants; indeed, so far as we can ascertain his views at the time of writing this notice, he intends to follow the admirable plan of making his lectures as much as possible a series of demonstrations with living plants.

Many gentlemen, either amateurs or professional men, are devoting their time to further this kind of instruction to ladies. At South Kensington, the Hon. and Rev. Francis Byng, and Mr. Owen, of the Museum, are taking an active part in the movement.

Professor Sedgwick, of Trinity College, Cambridge, and his brother, of Merton, have delivered courses of lectures, we believe, at Preston, Manchester, &c.

Most of the Professors of Natural Science at Oxford have given lectures to ladies at one time or another, Mr. Harcourt having delivered a course to "women and children;" and Dr. Child a series on Physiology last year at Clifton.

Mr. James Stuart, Fellow of Trinity College, Cambridge, is now delivering a course of lectures to ladies, in Liverpool, on Natural Philosophy, embracing the subjects of Light, Heat, Magnetism, and the most recent discoveries made by spectrum analysis. Papers are written by the class, and certificates of the 1st, 2nd, and 3rd class are given at the end of the course. The class numbers 165 students. In Leeds and Bradford, Mr. T. Aldis, of Cambridge, is delivering courses of lectures to women on the History of Physical Science. These gentlemen are lecturing under the auspices of the North of England Council, of which we believe Mrs. Josephine E. Butler, of Liverpool, is the President. Scientific lectures are also being delivered in Dublin and Edinburgh; in the former city at the Alexandra College for the Education of Ladies, by Dr. Macalister; and in Edinburgh by Professor Fraser on Natural Philosophy; and by Professor Tait on Mathematics. In addition to these it may also be mentioned that at Sir Patrick Dun's Hospital in Dublin instruction is given to soldiers' wives to prepare them for the vocation of army nurses. They are taught the laws of health, and the conditions of climate in relation thereto, of the principal stations of the British army; as well as the theory and practice of midwifery; and on passing a satisfactory examination they receive certificates of merit and pecuniary prizes. It is, of course, hardly necessary to state that at every Science School or Class in the United Kingdom connected with the Science and Art Department, women are not only admitted on an equality with men, but are treated with courtesy and consideration; but whatever may be said concerning the educational association of the sexes, we have found from personal observation, that, for the present at least and chiefly so far as women are concerned, they prefer being taught apart.

Having given this imperfect outline of what is being done in the way of general instruction in science to women, let us now inquire for a moment how and what it would be desirable to teach them with a view to their advancement in particular trades or professions. In this matter we may obtain some useful hints from what is doing abroad and at home for the education of artisans. For example, in some of the German towns special books and classes exist for instructing workmen in the theory of their trade, and in Liverpool lectures are about to be commenced with the same object. One course, which may serve as a type of this class of instruction, is about to be given by Mr. Norman Tate, on Chemistry applied to the practical arts. The first lecture is general, being on the relations of chemistry to industrial pursuits; then there are to follow two which will interest engineers, as they relate to Air, Water, Heat, Fuel in its application to the production of Heat, and the practical working of fuel for steam in furnaces, &c. Two follow on the Metallurgy and the Chemistry of Metals. After these there are lectures on building materials, stones, slates, bricks, mortar, cements, &c., for builders; earthenware and glass, for glaziers; pens, ink, and paper, for printers, &c.; paints, varnishes, and colours, for painters and decorators; horns, bones, leather, feathers, &c., and woods, for persons engaged as upholsterers and cabinet-makers—and one lecture on oil, fats, soap, &c.

Now, if we substitute the employments of women for those of men, and consider what branches of science are the most serviceable in those employments, we at once arrive at the solution of the problem. First, there are certain subjects on which all women should be tolerably well instructed, such as, for example, sanitary science; the broad principles to be borne in mind in coping with disease, or for the maintenance of health; and so much knowledge of anatomy as will enable a woman to bind a wound, or palliate the effects of an accident until medical aid arrives. Such knowledge is obviously indispensable to all women, whether married or single, and its diffusion would save many valuable lives in the lower ranks of society. But now we come to trades and handicrafts. Of course, each town has its special industries, and the professional men, or employers of female labour in Birmingham, Sheffield, Manchester, and other large towns need not be told whether classes in chemistry, or metallurgy, or physics, would the best subserve educational purposes amongst their workpeople. But what is more obvious than that a number of girls employed in working the electric telegraph would be the gainers by having a sound knowledge of electricity; or that young showwomen or saleswomen in any trade whatever might with advantage be taught certain branches of physical science? A girl who is constantly asked by customers whether she has goods of this or that colour or texture, would surely be the better for knowing something of the laws of colour, or the history of textile fabrics; and it would certainly do her no harm if she were acquainted with the chemical processes whereby the beautiful dyes and pigments with which she is familiar are obtained, sometimes from waste products.

What we suggest, then, is that the promoters of this excellent movement should not content themselves with imparting science instruction to young ladies, and such females as can afford to pay two guineas for a course or half-a-crown for a single lecture, and who can devote the forenoon to the acquisition of such knowledge. They should open evening classes, in which instruction should be given to women of the industrial classes (in which are included shopwomen), and to female teachers in national and other schools. To these the charge for admission should be nominal, whilst the character of the instruction to be imparted should completely accord with the trade or vocation of the recipients.

V. ON IDIOCY.

By P. Martin Duncan, M.B. Lond., F.R.S., &c.

What became of the idiots in the days of antiquity? Were there any amongst the early races of mankind? How is it that they are hardly mentioned by classical authors, and not noticed at all in Holy Writ? These are questions upon which those who are aware of the multitudes of idiots in the most highly civilized modern communities may speculate freely, but not very satisfactorily. The term idiot is of course Aristotelian. The existence of peculiar members of the human family who were "solitary" was known to the founder of that philosophy, and he clearly recognized the absence of the *vie de relation* amongst those he so well and aptly termed "ἴδιος" in kind. Children and adults who could not be communicated with, and who could not place themselves *en rapport* with others, were considered to be "solitaries;" they were beyond the sympathies, and were heedless of the love of the human race, and they were incapable of expressing the desire for or of seeking companionship. Probably Grecian idiots were very much akin to those of modern date in their deficiencies and peculiarities. They stared open-eyed by the hour, or they waved their hands about, beslavered their bodies, and wearied the beholder with automatic movements. They were as heedless of the weather as of the voice of authority, and they had neither reverence for the priest nor admiration for the goddesses or their living representatives. Alone amongst the multitudes, thoughtless amongst the philosophers, unloving when embraced, caring for no one, having neither friends nor foes, the "solitaries" of old were not unsurrounded by a faint atmosphere of sanctity even amongst the Greeks. They were unlike all other children when young, and could not be associated with in mental communion when old. They had no greed of gold; food they did not live for; luxury they were careless about; and of ambition they had none. The Helot might look upon the heedless solitary with slight respect, and call him a fool like a practical Anglo-Saxon; but his philosophic master, with his yearnings after the abstract and unknown, and with his dim misgivings concerning his own origin and future state, evidently associated the condition of his fellow-mortal with a mysterious and personal relation to the gods. He gilded the gingerbread humanity with a halo of sanctity, but the slave doomed to work did nothing of the sort. The men who recognized something more than a fiction in the myth of Prometheus gazed into the fixed eyes of the "solitaries" and speculated upon the possibility of the existence of an inward life of thought behind those dull orbs, and of a close affinity with the hidden intelligence of Zeus. Was there an Elysium within and a Tartarus clouding the without? Was there a curse which still could not extinguish the celestial fire? Bound with iron on the rock, torn by the everlasting bird, ever living, never dying. Thus with the type of organic life, was it thus in degree with the living example of a mindless body? There was no aberration evident to the thinkers of old in the "ἰδιος;" he was not chased by the Furies, but he was bound with invisible chains. Psyche was hidden, but the Satyr was free. The priesthood could but recognize some of the psychical conditions of the solitary in the exhausted and mentally collapsed state of the oracular virgins after prolonged religious excitement, and after the influence of the ritualistic therapeutics of the day had ceased to stimulate. These thoughts were probably common enough in a land where nature was luxuriant and where incessant toil was not requisite for existence. Farther to the east, where the struggle for life has never been great, there has been no hesitation in asserting that the idiot and the insane are under the especial care of the Deity; and amongst the followers of Mahomet the first of these has ever been looked upon with awe from the apparently willing self-exposure to the noonday sun, to the bitterest cold, and from the total disregard of consequences.

There is nothing in the cuneiform writing of the Babylonians nor in the hieroglyphs of the Egyptians to denote the existence of idiots during the time when those empires flourished; and it is very remarkable that there should not have been any notice of the idiotic state mentioned in the Book of Leviticus in the catalogue of those physical defects which were to prevent the priest from taking an active part in the ceremonial of the Tabernacle.

If misery, social degradation, and the free indulgence of the animal passions involve idiocy, there ought to have been plenty of it during the whole of the Roman Republic and Empire wherever the eagles rested. But there is much silence on the subject throughout the Latin authors. There were idiots in those days, and the practical Roman looked upon them as useless entities. They had no sanctity in his eyes, and hence their probable rarity. Doubtless the unfortunate children were neglected, and there is much reason for believing that they were "exposed." A congenital idiot soon begins to give trouble and to excite unusual attention; moreover, unless extra care is given to it, death is sure to ensue in early childhood. There are some very curious passages in the Latin classics that refer to the burial without cremation of very young children, and it is evident that although the laws against intramural sepulture were very stringent, there were instances where it took place surreptitiously. There is some reason for believing that many of the babies whose skeletons are now and then found close to Roman villas in this country and on the Continent had been buried there before teething had commenced, and that they had died from a peculiar incapacity for receiving nourishment in the usual way. This defect is common enough in profound idiots. Under the most favourable circumstances the Roman infant had a sharp struggle for existence, and the amount of the mortality of the young may be estimated, if we leave the question of idiocy out, by the number of skeletons discovered in the "suggrundaria"—under the eaves and close to the walls of houses. At Chesterford * no less than fifteen skeletons of infants were found close to the walls of a Roman villa discovered in 1852. The bodies were associated with a corresponding number of small vessels of Roman manufacture. It would seem that their parents had done all in their power by providing them with nourishment to soothe them and stop the crying, which Virgil, in the narrative of the descent of Æneas to Hades, in the 6th book of the Æneid, mentions thus:—

> "Vagitus et ingens,
> Infantumque animæ flentes in limine primo."

The shades of the children were crying, and on the first threshold, that is just without the doors—an allusion no doubt to the place of their sepulture. The laws against intramural burial extended to the case of children who were subject to be buried in the cemeteries but not to be burned. Pliny tells us that children cut their teeth in the seventh month !!! and proceeds to inform us that it was not customary to burn their bodies before that time. Juvenal also describes the funeral of a child without fire—

> "Terra clauditur infans, et minor igne rogi."

Fulgentius says that baby bodies were not burned until they were forty days old. There is, then, some reason for believing that the interment laws were broken in the case of such children as were idiotic and still-born. These were buried quietly in the "suggrundaria."

Those idiots whom we call simpletons, and who are not really solitaries, but approach the lowest types of the perfect in mind, were doubtless common in those Roman families where there was wealth and freedom from the usual active competition with the world. Doubtless there was many a big Roman, solemn and staid-looking, who was studiously silent and dressed in the quietest toga, just as there are magnificent-looking men, but, oh, how simple, who now-a-days follow the wise precept of holding the tongue and wearing black. The range of mental deficiency, from the true solitary through those who are mimics and mischievous incapables, to the solemn and sometimes witty fool who just verges on the

---

* An admirable description of this discovery, from which I have quoted largely, is in the 'Trans. Essex Arch. Soc.,' 1858, by the late Lord Braybrooke.

most stupid of perfect mankind, was not noticed by the Roman alienist physicians.

There are no notices of idiots in the time of Arabian learning, when Europe was linked on to civilization by its clergy; and the affliction is never seen, so it is said, amongst the pure Arabs of the present day, who continue generation after generation to marry their uncles' daughters as a matter of course. This intermarriage occurs in many nations, living in what we call a very absurdly savage state, and yet idiots are either rare or absent amongst them.

The history of idiocy is then to be written in a very small space, yet the condition is one of the greatest curses of modern times.

There are at least 10,000 pauper idiots in England and Wales, and there are 1760 idiots confined in workhouses and lunatic asylums in Ireland, but how many there are out of doors is unknown. In France there are 2·5 idiots born in every 1000 births. There are no statistics that can decide how many idiots there are in private families in Great Britain, but every alienist physician knows their number is legion. They are kept out of the way, shut up, being looked upon as a disgrace to the family, for people do not discriminate between the causes that give idiots to the drunken and reprobate, and those that induce idiocy in the families of the purest in mind and who lead the gentlest of lives. There is no greater trial in a family than the presence of an idiot child, for it not only attracts too much maternal care, but it affords, as it grows, a bad example to the other children. Supposing that there are two idiots born for every thousand of healthy children, what a mass of hidden suffering there must be around us for which there is hardly any relief.

The percentage of idiots increased in Ireland as the general population diminished after the famine and during the subsequent emigration; it is very large in France, whose population is at a standstill; it is great in North America, where the population is most mixed; and it is greater in those English counties where there is an agricultural population, earning poor wages and looking to the Union as their haven of rest, than in the others. In Herefordshire there were, a year or two since, 111 idiots (pauper) in 106,796 inhabitants, or 1 in 962; in Wiltshire, 237 pauper idiots in 236,027 inhabitants, or 1 in 995; in Berkshire, 200 pauper idiots in 205,625 inhabiants, or 1 in 1028; and in North Wales, there is a pauper idiot for every 906 souls. With these figures before us it is of no use hiding our national skeleton; the closet-door is opened every year during the census of pauperdom, and the grim fact constantly increases. Possessing what we call the highest civilization, we European and North American nations produce more useless children than those savages who have little or no civilization.

We present, as peoples, indications of defective vital force, which are not witnessed amongst those human beings that live in a state of nature. There must then be something rotten in some parts of our boasted civilization; and not only a something which has to do with our psychology, but a great deal more with our power of physical persistence. It is a fact that the type of the perfect minded just above the highest idiots or the simpletons is more distinguishable amongst the most civilized of the civilized, than amongst those who are the so-called children of nature. Dolts, boobies, and stupids, *et hoc genus omne*, abound in young Saxondom, but their representatives are rare amongst the tribes that are slowly disappearing before the white man. We notice a wild flower, and observe that it flourishes in the woods, on the hill side, and down in the valley; its growth is magnificent and the reproduction is invariable. We transplant the flower into our gardens and care for it, and year after year its beauties remain in perfection; but if, in order to improve upon nature and to attempt to excite some hidden powers of growth, the plant is removed to the greenhouse and "cultivated," one system of vital phenomena invariably extends to the detriment of another. The vegetative and the reproductive systems are constantly antagonistic under the artificial treatment. You select splendid flowerers and strain every function to perpetuate the unusual inflorescence; but what occurs in the majority of cases? The outside is splendid, but everything else is sacrificed. You have outraged nature and have obtained the homologue of an idiot in a highly civilized community. It is the same with animals, and there is not much difficulty in "cultivating" any of our domestic pets until the progeny becomes stupid and very difficult to keep alive. Nature only cares for those organisms that possess all their functions in perfection, and the struggle for existence soon militates against those whose nutrition is defective or hard to influence. It is clear that there are some vices and defects in our civilization that are positively antagonistic to the production of a population perfect in mind and body, and negatively so also by evolving evil out of what is hardly otherwise than normal in so-called savage nations. The marriage of close relations, over-indulgence in food and spirituous liquors, continuous misery and moral degradation, hopeless poverty, over-work, agricultural drudgery, everlasting hebetude from the general sameness of surroundings, are amongst the proximate causes of congenital idiocy, and of that kind which develops itself in healthy children some time after birth, and which has similar phenomena.

The production of insanity and the development of idiocy are two different things, and it is one of the signs of the times that idiots are being separated from lunatics. The public mind still associates the two conditions, and the public purse is certainly well opened for both. Some pathologists deny congenital idiocy, and assert that the healthy baby develops the disease by thumb-sucking, but experience proves to the contrary, and a long list of material cerebral defects and deformities indicates that although the laws of teratology are often beside the question, there are structural peculiarities sufficient to explain the mental condition. The following selected cases will give an idea of the vast amount of difference in the so-called idiotic. The first is the history of a profound idiot; the second refers to a case which had locomotive powers; and the third relates to a child that enjoyed slight communication with others.

A boy, six years of age, is a well-formed idiot of the lowest class. The head is not badly formed. The face is pale and is without expression. A slight smile is now and then seen when he is much pleased, but there is no evidence of intelligence to be derived from the action of any of the facial muscles. He stares fixedly, and will not follow the hand with his eyes when it is waved to and fro. His power of vision is very slight, and at times the eyes wander from one object to another in an unmeaning manner; or they remain fixed upon space while the head is slowly moved from side to side. The ears are well formed externally, and he hears, but will not listen when required to do so. The nose is well formed, and the sense of smell exists. His taste is defective, and he can barely distinguish between nice and nasty things. The saliva runs slightly from the mouth, which is usually open. The upper lip is large, the teeth are irregular and bad, and the arch of the palate is high. He has no voice, and cannot hum a tune, and he rarely shrieks or cries. The body is well made, but very weak in its muscular development. The lungs are healthy. The heart is very feeble in its impulse, and its pulsations are slow. The erect posture soon induces faintness. The arms are thin and well formed, and so are the hands. He can move the hands at will, but he cannot grasp in an easy and perfect manner; they are generally in motion, being waved in the air before the face. The legs are thin. He cannot stand nor sit upright. He can kick about and roll over, but the usual posture is on the back with the legs drawn up. He does not recognize his mother, there is no intelligence; the emotions barely exist, and even passion is rare. The habits are those of the earliest infancy. He has to be treated like an infant of a few days' old. He does not suck, but takes food from a spoon or with his fingers, but he cannot swallow unless the morsel is placed far back on the tongue. He sleeps well and drinks with difficulty.

The intelligence is at the lowest ebb, the power of muscular co-ordination is very defective, and the inability to walk or to use any of the limbs satisfactorily characterizes the case. The child had not the spontaneousness of an infant a week old; and six years of care only produced the ability to sit up and to notice a very little. That the idiocy was congenital there can be no doubt. It was evidently so in the next case.

A female child, aged six years. The child is small, with a thin long body, high shoulders and extremities. The shape and size of the head may be gathered from the following measurements:—

	Inches.
Circumference	17·5
Nasal spine to occipital protuberance	11·5
Mastoid process to mastoid process	12·75
Great diameter	6·75
Small diameter	4·75

The forehead is very small. The face is small and pale. When quiet, there is nothing idiotic about the expression, but when, as is usually the case, she is restless, the mouth is noticed to be widely open, and the entire hand is often stuffed into it, the aspect being very silly. Considering her age, the expression of the face is very vacant. The eyes are large, and vision is imperfect. She looks about in a vacant listless manner, stares fixedly for a long time, and possesses barely any power of fixing the eyes to examine an object. The ears are large. She hears, but does not listen. The nose is well formed, and its sense is perverted. The mouth is very large, and the lips also; the teeth are irregular and the tongue is swollen. The saliva runs in quantity from the mouth, and there is much discharge from the nose. She makes unmeaning sounds, screams, and cries, but rarely laughs. She can sit up of her own accord, lie down, turn round, and stand in a curious stooping posture. She cannot walk slowly in a straight direction, but sets off one shoulder first, and, like a tipsy man, takes a staggering run to the left, then to the right, and so on. She usually brings her elbow close to the side, elevates the wrists, and allows the back of the hands to drop forward in running. The whole proceeding gives her the appearance of a rat. She cannot employ her hands in any useful manner. Automatic movements of the body, see-saw of the head from side to side, and of the hands before the eyes, are frequent. Constantly in motion, when not erect she twists her body and agitates her arms. She does not recognize those who are kind to her, does not care about her food. She cannot be made to attend, to listen, or to do anything. Her emotions are easily excited, and she will scream, open-mouthed, by the hour. Everything placed in the hand goes to the mouth without discrimination. The scalp is tender to the touch. She is quite infantile in her habits. She sleeps badly, and has great thirst. She can move about, and thus has more nervous force than the first case, but she has not the intelligence of a child a month old.

The third case is a male, aged eleven years. He is a slim, long-limbed boy, with a long and narrow head. The following are the head measurements:—

	Inches.
Circumference	19·5
Nasal spine to occipetal protuberance	12·5
Mastoid to mastoid	14·
Great diameter	6·5
Small diameter	5·5

The face is hideous, and is peculiarized by its constant contortions. The mouth being opened, shut, and twisted, the brow knit, and the whole head turned in the oddest manner. The skin is sallow, and is usually moist from the quantity of saliva flowing from the mouth. There is an expression of happiness when he is spoken to and noticed. He squints and suffers from fixity of vision, and also from restless movement of the eyes. He has a little power of directing his vision, but he looks at things out of the corners of the eyes, and lifts his chin obliquely in doing so. The ears, nose, and mouth are well formed. He hears, and can be made to listen slightly; moreover he notices music. He cannot speak, but howls, cries, and laughs. The muscles of the body and limbs are flabby. His arms are long, and the right wrist is bent upon the fore-arm. He is club-footed, can balance himself on his toes if held, and has much power over his limbs. He cannot walk nor stand alone. He balances himself when sitting, thrusts out his legs and arms, and presents a very singular appearance. He has but slight power of attention; he can discriminate between persons and different things, and he has therefore slight evidences of intellectual perception and memory. The emotions are easily excited. He knows his mother, his attendants, and those who often notice him. His habits are those of a child a few months old. He cannot do anything for himself. His meat has to be cut up small, and placed on the back of the tongue. The chin is then oddly rotated upwards, and the morsel is swallowed with difficulty. He knows his food. He rolls his head a good deal. In six years he learned to stand alone, and gained a little more intelligence, but he is still silent and a solitary.

These cases are those of congenital idiots, and the first is evidently lower than the last in the mental and physical scale. The gradation towards the more highly developed amongst the feeble-minded is pretty well exemplified in the following cases:—

A girl, aged fifteen years, is high-shouldered, has a large body, short limbs, and a small head. She sits with her head on one side, looking over one shoulder. The eyes are fixed upwards on vacancy, and the chin is poked forward and upward. When she moves from this position the chin is not lowered, and the attitude assumed is terribly simian. She walks badly, and she steps short, being lame.

She can run a little, and sits up; moreover, she can get in and out of bed herself. The features are irregular, the eyes are deep-set, and the nose is small and flat. The lower jaw is large and prominent at the chin. There is some power of expression in the muscles of the face. She squints with one eye, but sees well, being incapable, however, of having her visual attention directed. The eyes wander much, and are also often fixed with an unmeaning "brown study" stare. The ears are large, and their sense is acute. She is fond of music, and will listen sometimes. The senses of smell and taste are natural, and there is no excess of saliva. The hands are clumsy, and she can spoon her food, but she cannot dress herself. She makes herself useful by holding things. She has slight memory, which is restricted to persons and things with which she is in constant contact. She remembers a few names. She has a few ideas and fancies, and is very sensitive to external impressions, although the result is transitory. She has ideas of self-preservation, and is occasionally very passionate, but usually is placid, good, affectionate, and obedient. She is incapable of being taught anything, except a few household matters.

A girl, aged eleven years. She is tall and thin, and has a narrow and flat forehead. The face is large, and the mouth also. It is generally open, showing the ragged teeth, and permitting some slavering. The face is expressionless, the eyes are not often fixed, but the head is constantly turned about, looking for new objects. She has slight powers of speech. The body and limbs are well formed; the walking is very badly performed; the muscular co-ordination is defective, and she is much given to jerking movements. She is gay, very full of fun, and affectionate, and occasionally passionate. The memory is very weak, and the powers of comparing, of perceiving intellectually, and of attending, barely exist, but the attention can be attracted.

A girl, aged twelve years, has a small head with a high sugar-loaf shape, Chinese-looking eyes, and a long, projecting lower lip. The face is very placid, without expression when she is quiet, but there is much capacity for expression. The eyes are weak, and she stares long and fixedly; the nose is flat. She is lop-eared, but hears fairly well; she listens indifferently, and sucks her large tongue. The teeth are deficient and bad. The body is well formed, the legs are long and straight, but the arms are bowed. She walks and runs badly. She speaks a few words. The memory, perception, and attention are at a very low ebb. She is listless and sedentary, bashful, good-tempered, gay, and knows those about her. She is obedient, and knows what is expected of her.

A stout and well-made boy, aged eight years, has a well-formed body and limbs. The shape of the head is good, and the face is large. Its expression varies. The eyes are well formed, but he suffers from wandering vision. The senses of hearing and smelling appear perfect. The mouth is large, and he slavers. He can hardly enunciate a syllable, but can sing slightly. His muscular co-ordination is defective, and he waddles in his gait. He is much below the standard of intelligence amongst perfect children of his age, yet he is high amongst the idiots of his class. He understands a great many words, and attends tolerably. His memory is very weak, but he remembers many things he is told to do. He knows his own things, he can compare, and he has a slight idea of consequences, but foresight and imagination do not appear to exist in his mental constitution. The intellectual perception is very slight. His attention is easily obtained. The emotions are readily excited. He is bashful, good-tempered, obedient, affectionate, and gay. He is restless and mischievous. He knows very little. He feeds himself with a spoon, but cannot dress himself. The dulness of comprehension is very great.

The following case illustrates the highest amongst the upper class of idiocy, but the man had been many years under supervision and training:—

A tall, powerful man, aged forty-four years. The face is expressionless and dull, but good-tempered. The special senses are perfect, and the speech is rather hesitating, but otherwise distinct. The body and limbs are well made and are on a gigantic scale: he is 6 feet 3½ inches high. The gait is slouching, but the general coordination is unusually perfect. His intellectual powers classify him high amongst the feeble-minded. In spite of careful training, his stupidity, obtuseness, slowness of comprehension, and defective power of perception are constantly noticed. Any trivial ailment diminishes the mental powers in a marked degree. He reads slowly and well; writing is moderately performed; he has slight arithmetical powers, and a good slow memory. He is very good-tempered and amiable, is obedient and placid as a rule, but easily roused, and religious. He is a very good son and a careful labourer. He requires looking after as regards his personal cleanliness. There is no relation in his work between the labour used and the degree of force required. He is generally incompetent when out of supervision. He works in the garden and takes messages. The want of spontaneity, the general dulness and slowness of comprehension, the slightly defective speech and the slouching gait, are very distinctive.

Most of the so-called idiots may be arrayed side by side with one or more of these cases, and the necessary restriction of the term to the most debased becomes very evident after considering the positive mental peculiarities of the latter examples. They all have some peculiarities in common. Thus a defective state of muscular coordination is invariable. The muscles may act well separately, but they do not combine their action properly to a common end. This is in consequence of a grave nervous defect, and we owe the diagnostic to Seguin. It is very remarkable how writers who scribble about idiocy, without ever having had an opportunity of spending days and weeks with the unfortunates, and who display such arrogant ignorance of their subject when they review the labours of practical observers, invariably neglect to notice this great physiological defect. The idiot hears, but as a rule cannot enunciate a syllable correctly, and there is always a defect in the voice. Yet he may open and shut his mouth well, move his tongue properly, expand his chest, and cause some vibration of his vocal cords. But the complex association of movements to the common end of the production of voice is impossible from defective co-ordination. Again, no idiot walks or runs perfectly. The defective combination of the great number of muscles employed to produce graceful locomotion is evident. The greater the idiot, the more defective is the co-ordination of his muscles.

Automatic movements are also common to all the cases, and they bear a direct relation to the profundity of the idiocy. Such are balancing the body and waving the hands to and fro, moving the head from side to side, see-sawing with the body, moving like a pair of open compasses, first on one foot, then on the other, and going through all these unintentional gymnastics, one after the other, with fidgety regularity. The movements will go on hour after hour, and even for days. Fixity and wandering of the eyes and of vision are common. The child stares, in the first instance, upon vacancy, and the attention is not to be attracted; but in the last, the child moves its eyes listlessly hour after hour. The mental defects, want of regard of consequences, and want of foresight, are as evident as the absence of imagination and of all notion about abstract ideas. In idiocy there is not a weakened condition of a perfect mind, but many of the mental phenomena are not possible. The children have ears, and hear, but they do not listen. The memory of things is slight, but the recollection of events, and of time in respect to events, is rarely observed.

Sometimes one faculty is brighter than the others, and, dim as it is, it strikes the superficial thinker; but really the most brilliant gift of an idiot is far below the corresponding average of the perfect man of the same age.

The phenomena of idiocy are occasionally developed, in consequence of disease of the brain, in children and adolescents who were born in perfect possession of their faculties; but an amount of inanity is usually superadded, and of wild, odd wit also.

VI. THE FRENCH IMPERIAL SCHOOL OF FORESTRY.

By Alfred Pengelly, B.A. Cambridge.

At a time when we see fully recognized the importance of the maintenance of forests, both for commercial purposes and also for the great influence which they exert on climate, especially in tropical countries, it may not be uninteresting to the public to have set before them the steps which have been taken by the British Government for placing our Indian forests under careful and efficient management.

We learn from the Report of the British Association for 1868,* that at the meeting of this body in Edinburgh in 1850 a committee was appointed to consider "the probable effects, in an economical and physical point of view, of the destruction of tropical forests." Their Report was presented in 1851 at Ipswich, and is printed in the volume for that year. "Attention was thus directed in India to the importance of preserving every influence which tends to maintain an equilibrium of temperature and humidity, of preventing the waste of valuable material, and the special application to their various uses of the indigenous timbers of the country. A few years later forest establishments were sanctioned in British Burmah (1855), and in the Madras Presidency (1856); and in 1864 Government laid the foundation of an improved general system of forest administration for the whole Indian empire, having for its object the conservation of state forests, and the development of this source of national wealth. The appointment of Inspector-General of Forests was made, and it is now held by Dr. D. Brandis, formerly the able conservator in British Burmah."

It is through the combined exertions of Dr. Brandis and Dr. Cleghorn, the latter the author of the paper just quoted, that the plan of sending young men to France and Germany to undergo a special training in forestry has been adopted.

About the year 1866 Dr. Brandis visited the forests of England, Germany, and France, and the Forest Schools of the latter two countries, and, as the result of his observations, advised the Government to pursue the course just mentioned. In conjunction with the French and German authorities, he drew up regulations respecting the studies of the English pupils whilst at the Forest Schools.

At the end of 1866 our Government announced their intention of sending out five young men, duly qualified, for the Forest Department of India.

---

* 'On the Distribution of the Principal Timber Trees of India, and the Progress of Forest Conservancy,' by Dr. Hugh Cleghorn: 'Brit. Assoc. Rep.,' p. 91. 1868.

Candidates for these appointments were to undergo a preliminary examination in London in Arithmetic, Algebra, Trigonometry, English Dictation and Composition, the Natural Sciences, and Drawing. A knowledge of French or German was also required, and all the candidates had to pass a strict medical examination. Those who were successful were then sent either to France or Germany to study the science of Forestry, as taught in the old established schools there. It is to the course of instruction in the *Ecole Impériale Forestière*, established at Nancy, in the department of the Meurthe, that the present article will be devoted.

This establishment is an offspring of the German schools, having been founded in 1824, when M. Lorentz, who had studied Forestry in Germany, was made Director. It is not to be supposed, however, that the French and German systems are identical. Any one, reflecting on the characters of the two nations, would be prepared to find that the German system was more artificial, and entered much more into minutiæ than that pursued in France. At all events such is the fact.

Before the establishment of the Forest School in France the administration of the forests was carried on by officers of the army, detached for the purpose, but who had received no special training for the service. This is pretty much the state of things that has obtained in India up to the present time, such officers, however, being selected as were specially fitted for the service by their botanical or scientific knowledge.

Those candidates who were sent to France had to spend eight months at Haguenau, near Strasbourg, before entering the school at Nancy, partly to ensure such a knowledge of French as would enable them to follow, with facility, the lectures of the French professors, and to take copious notes of them; and partly to give them a practical knowledge of the operations which are carried on in a large forest, such as that of Haguenau. In November—the commencement of the scholastic year—they proceeded to the *Ecole Impériale Forestière* at Nancy, where, with the single exception of lodging in the town instead of at the school, they were submitted to the same regulations as the pupils of the French Government.

We shall now proceed to give a brief account of the course of study during the two years over which it extends. In each, the winter season is devoted entirely to lectures and study connected with them: a portion of each day is also devoted to drawing, either for the purposes of surveying, or the construction of bridges, saw-mills, &c. After Easter commences what may be called the practical or out-door part of the course, when the whole School goes out to see the forests, and generally to apply what has been taught in the lectures. During this time, in order to prevent confusion, the School is divided into sections, each consisting of six or seven pupils, who work together, and are responsible only for that part of the task allotted to them. In some cases, as for instance in the Triangulation to be hereafter mentioned, the results obtained by the six or seven sections are combined on the return to Nancy, so as to form one whole.

The subjects treated of in the lectures may be classed under four heads:—Sylviculture, Applied Mathematics, Natural History, and Law. These lectures are carried on simultaneously, two subjects being taken on each alternate day. The Sylviculture treats first of climates, soils, and the different kinds of trees, giving their requirements, their natures, and the qualities of their timber. Then follow a description and discussion of the different methods which have been, or are still applied to the treatment of forests; in fact, a kind of introduction to the whole subject, giving a good general view, without entering into details. It must be remembered that many of the students have never seen a forest, and that therefore it is of importance to give at the outset a correct general idea of what a forest ought to be.

Under the head Mathematics is included all that is necessary for land-surveying, levelling, &c., the construction of houses for forest guards, and road-making.

The Natural History is confined to a course on Botany and Vegetable Physiology.

The Law treated of is an introduction to general principles, with a short course on the code respecting the chase.

For each of the four kinds of subjects there is a professor and an assistant-professor.

The following table shows the distribution of the work for the students of one year:—

	Monday, Wednesday, and Friday.	Tuesday, Thursday, and Saturday.
8—9.30.	Natural History	Study.
9.30—11.	Study	Sylviculture.
11—12.10.	Breakfast	Breakfast.
12.10—1.30.	Drawing	Drawing.
1.30—2.0.	Recreation	Recreation.
2.0—3.30.	Law	Drawing.
3.30—5.0.	Study	Mathematics.

For those of the other year the arrangement is exactly the same, except that the days are interchanged.

In order to ensure attention to the lectures, any student is liable to be examined during the afternoon study time on any subject treated of in the last ten lectures. The list of those to be examined is posted up every day at 12.10, so that a short time is granted for revision. These examinations occur irregularly; hence there is nothing to warn a student when he is likely to be examined. All that he knows is, that, come when it may, it will be on one of the subjects to which the lectures for the day are devoted.

At the end of the lecture session, generally before Easter, there are examinations on the whole of each course. These, as well as those already spoken of, are *vivâ voce*, and in order to prevent partiality the questions are chosen in the following manner:—A book is published before the examinations commence, giving for each subject thirty sets of four or five questions, numbered from one upwards.

The student on arriving draws one of thirty numbers placed in a bag, and he is then examined on the set of questions indicated by the number drawn. The professors, however, reserve the right to ask a question not indicated in the set drawn. These examinations last from half to three quarters of an hour. For each there are three professors; one acting as president and the others as assistants. Each gives marks, and the average of the three estimates determines the final mark for each examinee. Every student has three clear days to prepare for each examination.

Marks are given also for all the drawings executed during the year. These, like those for the smaller examinations, count only for a proportion of their value, and are added to those given for the final examination in order to the determination of the class list.

The studies after Easter form the most enjoyable portion of the whole course. In the first year a month is spent at some place, such, for instance, as Gérardmer in the Vosges, where there are forests, portions of which are surveyed by the students, who are divided into sections, as already intimated. Immediately on the completion of the observation of angles and of the chaining, rough plans are made in order to detect and correct any grave error before leaving that part of the country, and more finished plans, combining the results of all the sections, are executed on returning to Nancy.

In this district, too, a road is planned out, each section taking a part of the work.

These practical operations are of very great importance, as they serve to elucidate what has been said in the lectures, and to impress each point more firmly on the mind.

After this comes the very best of the whole year,—the time spent in making a tour to see some of the principal forests of France. The parts visited are the Vosges and the Jura, and, of course, in this manner the school passes through some of the finest scenery of the country.

The object is twofold: first, to see the forests themselves; and secondly, to study general natural history, and to make a collection of plants for an herbarium.

The Professors of Sylviculture, who accompany the school, describe the soil, climate, and position of each forest, the treatment to which it has been subjected, and the effects of the operations performed therein, praising the good and condemning the bad. The students take notes, which are to aid them in writing a memoir on returning to Nancy.

For the second object, the Professor of Natural History accompanies the school, and gives notes on all the geological formations which present themselves, and also on the different plants which he directs the students to collect. These are such as are found in forests generally, or which denote the presence of some particular soil. The effects of the ravages of different insects, with their modes of life, &c., are also pointed out.

On returning to the Forest School, a general memoir of this tour is made, and each student arranges his herbarium, labels being affixed to the specimens, denoting the place and date of finding, together with the class, family, genus, and species.

After all this has been finished, come the examinations for the end of the year. In these, questions can be put on any part of the course of lectures as well as of the practical course; or the student may be required to give a description of any forest visited, or to state where he has seen any particular fact illustrated. Marks are given for the examination itself. To these are added a proportion of those gained in the examination at the close of the lecture session, as well as of those for the exercises done in the practical course, and thus the place in the class-list for the year is determined.

The examinations are finished by the middle or end of August, when the vacation, which lasts until the commencement of November, begins.

In the second year, lectures are delivered on the same four classes of subjects.

Those on Sylviculture commence with a revision of the first year's course, and go on to describe the "Aménagement" of a forest. The "Aménagement" forms the basis of the management of each forest, giving, in fact, the plan on which it is worked, regulating the thinnings and clearings to be applied to it, the age at which the wood should be cut, and the amount that can be cut yearly without endangering the existence of the forest.

Perhaps the best idea of the meaning of the word "aménagement," of which there is probably no exact equivalent in English, will be gathered from the following definition given in the course at the Forest School:—

"L'aménagement d'une forêt est une opération qui consiste à régler le mode de traitement et les exploitations de cette forêt en vue des besoins du propriétaire et de la consommation," which may be anglicised thus:—The aménagement of a forest is an operation which consists in regulating the mode of treatment and the cuttings in this forest, in view of the necessities of the owner and of the general consumption.

The Mathematical lectures consist of a course on Mechanics, with special reference to the different kinds of saw-mills, and a short course on Triangulation and the use of the Theodolite.

Those on Natural History embrace three courses: one on Mineralogy, one on Geology, and one on Zoology. Of the last, perhaps the most important part regarding the forests is that which treats of insects and their ravages, and the higher animals by which they are kept in check.

The legal studies are restricted to forest law, treating specially of the French *Code Forestière.*

As in the former year, examinations are held constantly on the last ten lectures, as well as at the end of the lecture session and at the end of the year. They are conducted in the manner already described.

After Easter the school commences its travels, but there is now no real tour. The students go to some locality where the different kinds of saw-mills can be seen in action. Drawings of the machinery are made from actual measurements, and are coloured so as to indicate the material of which each part is composed. General directions are given to the students, and each is at liberty to take what sections he thinks most necessary. They are also to obtain all the information needful to determine the efficiency of each machine and the probable cost of construction, so as to be able to deduce its value as a commercial speculation.

The School is also required to make a triangulation of a tract of country, and for this purpose they adopt as a "base" some line which has been calculated by the Ordnance Survey of France, which would, of course, be more exact than one measured by the aid of ordinary instruments. In this triangulation the method of sections is again adopted, each having a certain number of signals assigned to it, and being responsible for the exactitude of the results obtained.

The practical application of the course on the "Aménagement of Forests" is generally made in the forest of Haguenau, which in one part consists of "hard wood," oak, hornbeam, and beech, the first being often remarkably fine; whilst the other part is almost exclusively composed of Scotch fir. The students have to form a plan for the "aménagement" of the portion of forest which is allotted to them,—generally from 1500 to 2000 acres. Of course, before proposing any scheme, it is necessary to know the contents and condition of the forest. In order to this, it is divided into parcels, homogeneous as to climate, soil, aspect, and also as to the kinds and ages of the trees found in them. Each of these is described, and they are then grouped so as to form masses which may as much as possible be cut at the same period, and in such a manner as to satisfy the rules laid down for the good management of forests. Two of these "aménagements" are executed here; one in the "hard wood" and the other in the Scotch fir. Another had before been effected in the forest of Haye, near Nancy, which has hitherto been treated as coppice, but is now gradually being changed into a real timber forest, in which the reproduction is to be effected by natural seeding. This "aménagement" had for its object to show how the change might be completely effected with as little loss and as much regularity as possible. These "aménagements" include the principal cases likely to occur in France.

In the principal Examinations of the second year the professors give specimens of rocks, plants, and wood to be determined. Respecting the plants the student is required to state the class, family, genus, and species to which each belongs.

For the final class-list a proportion of the marks gained in the first year counts with those of the final examination, which itself forms about half of the total, the other half being supplied by the marks of the first year, the marks at Easter of the second year, and those for the different exercises during that year.

These examinations bring the course at the *Ecole Forestière* to a close; and those who have satisfied the examiners have invariably been found perfectly competent for all their professional duties. Whether the system inculcated at the *Ecole Impériale Forestière*, with the modifications necessitated by the differences of climate, can be successfully applied to the forests of India, is the problem now awaiting solution.

The students who enter under the auspices of the French Government, must be between the ages of eighteen and twenty-two, thus resembling the majority of the undergraduates at our English universities. The contrast as to the discipline maintained in the two cases is very striking. From the table given above it will be seen that the whole day, from eight in the morning until five in the evening, is necessarily spent at the Forest School, for the students are not allowed to leave the premises, except during the hour devoted to breakfast. From five o'clock until ten in the evening they are at liberty to employ their time as they think fit, provided they do not infringe any regulation of the School.

The police of the establishment is carried on by three "Adjutants," one of whom is always in the room allotted to the men of each year during the study time; acting, in fact, as an usher, and reporting to one of the professors who holds the post of "Inspector of the School." The third has nothing to do in the School, but parades the town in plain clothes during the evening when the students are allowed to be out. The latter are obliged to return to the School at or before ten o'clock, and to sign their names on entering. If the signature is not in the customary handwriting of the student, he is liable to be put under arrest, that is to say, he is not allowed to leave the School during a certain number of days.

Arrived on the premises, they are allowed to be in each other's rooms until eleven o'clock, but after that hour each must go to his own room and remain there. To ensure this, and for the maintenance of order generally, an adjutant makes his rounds on the staircases, and has the power to enter any room, after having knocked. At midnight he retires to his room at the foot of the staircase. The other adjutants do not lodge at the School. New buildings have, however, been recently erected; and in future they will all be lodged on the premises. The supervision is thus very complete; in fact, seen from an English point of view, the students are treated rather as boys, than as men responsible for their own conduct.

In order to represent the School on any public occasion, to maintain internal good order, and to decide differences which may arise among the students, a "Commission" of seven members is elected. It consists of a "President" chosen from and by the students of the Second Year, together with a "Papa" and two "Commissioners" chosen by the men of each year from their own number. The President has only a casting vote. The commission is recognized by the authorities, and through it hints are sometimes given to the students in a semi-official manner, which to some extent mitigates the pressure of the School regulations.

An hour on alternate days is devoted to regular instruction in horsemanship, but beyond this there is no athletic exercise, a fact which contrasts strongly, and perhaps disadvantageously, with English public schools and universities.

The English students speak most highly of the uniformly kind manner in which they have been received by the French with whom they have come in contact, whether professors or pupils; and it is to be hoped that the kindly feeling thus commenced will be constantly maintained.

VII. THE FULLER'S-EARTH IN THE SOUTH-WEST OF ENGLAND.

By Ralph Tate, Assoc. Lin. Soc., F.G.S., &c.

In the early part of this year my honoured correspondent, M. Terquem, of Metz, applied to me for information respecting our Fuller's-Earth, as he was desirous to know the relations subsisting between the formation as developed in the province of the Moselle and in England. The account given of the Fuller's-Earth in our geological manuals is very meagre, and could serve very little my friend's purpose; but fully aware that such description did not embrace all that is known respecting the formation in this country, I had compiled the summary that here follows: and in addition supplemented our knowledge of the fossiliferous contents of the *terrain* by the determination of a large suite of fossils in the collection of the Geological Society. These new materials render no longer tenable the inferences that have been drawn on the affinity of the fossils.

The geological reader is aware of the great lithological and in part palæontological differences which exist in the Lower Oolitic strata at the opposite extremities of their range in England. In the belief that the present communication, brief though it be, is the fullest exposition of the history of the Fuller's-Earth in the south-west of England, I trust it will prove of service in future attempts to correlate satisfactorily some one of the members of the Lower Oolite of Yorkshire with that of the typical Fuller's-Earth.

I may state in passing that the Fuller's-Earth in the department of the Moselle has yielded more than 300 species of fossils, not including microscopic forms, which number nearly one hundred; M. Terquem* has divided the formation into three zones of life—the inferior characterized by *Ammonites Niortensis;* the median, by *Ammonites Parkinsoni;* and the superior, by *Ammonites Backeriæ.* No such divisions have been made out in the English beds.

Extent and Thickness of the Fuller's-Earth in the South-west of England.—With the other members of the Lower Oolite, the Fuller's-Earth has more or less of uniformity as regards its constitution and fossil contents from Dorsetshire to the borders of Oxfordshire. Throughout this tract, it presents an argillaceous character with thin beds of limestone and calcareous nodules. The underlying formation is, in every instance, the Inferior Oolite; but from the Dorsetshire coast to near Hinton, on the borders of Somersetshire and Wiltshire, it is overlain by the uppermost members of the Lower Oolitic series, and to the north of that locality the Great Oolite appears, and throughout the further extension of the Fuller's-Earth is the overlying formation.

---

* *In litteris.*

At Bridport, on the coast of Dorsetshire, the Fuller's-Earth attains a thickness of 150 feet; and near Bath, where it forms a conspicuous band, it is 140 feet thick; at Wotton-under-Edge, 128 feet; near Stroud, 70 feet; and in the north of Gloucestershire, as near Cheltenham, it is further reduced to a general thickness of from thirty to forty feet. It appears at Sherborne, near Burford, to the north-east of Cheltenham, and does not extend as far east as Oxfordshire, beyond which the Stonesfield slate rests on the Inferior Oolite. The horizontal extension of the typical Fuller's-Earth in the south-west of England, which is about 180 miles, is very much the same as that of the Upper Lias Sands—preserving a maximum thickness from Bridport to Bath, but attenuating rapidly to the north and east, and finally thinning out a little to the north-east of Cheltenham.

Lithology.—The peculiar mineral from which the formation derived its appellation, is confined to particular districts, as around Bath and Stroud, and where it does occur, constitutes but a very small portion of the thickness of the formation. This *Fuller's-Earth* is used in fulling cloth. The lithological characters of the formation may be gathered from the following sections:—

1. *Cliff at Watton Hill, west of Bridport Harbour*, "composed principally of blue clay, grey marl, and marlstone, with subordinate beds of imperfect stone; thickness of 150 feet; the base reposes on the Inferior Oolite, and the formation is covered by the Forest-Marble."*

2. *Bath*, in descending order:—

	Feet.
A. Blue and yellow clay, with nodules of indurated marl	30 — 40
B. Bad *Fuller's-Earth*	3 — 5
C. Good *Fuller's-Earth*	2·5— 3
D. Clay, containing beds of bad *Fuller's-Earth* and layers of nodular limestone and indurated marl	100
	135·5—148

Bed D encloses one or two strata of a tough, rubbly limestone, which is commonly called Fuller's-Earth rock, and bears considerable resemblance to Cornbrash. This rock is always accompanied by an immense number of *Terebratulæ*, and *Mya angulifera* and *Isocardia concentrica* are almost invariably found in it.†

3. *Slaughterford, East Gloucestershire:* ‡—

	Feet.
White marls, with occasional stonybands	25
White and grey limestone, and Fuller's-Earth rock ..	10
White and blue calcareous clays with *Terebratulæ* ..	30
	65 ‡

4. Near *Cheltenham.*—The deposit consists of regularly bedded blue and yellow shales, clays and marls, with occasional courses of

---

* De la Beche and Buckland, 'Trans. Geol. Soc.,' 2nd series, vol. iii. (1830).

† Lonsdale, Geol. of Bath, 'Trans. Geol. Soc.'

‡ Hull, Mem. Geol. Surv., sheet 34.

rubbly limestone or calcareous sandstone. Most of the limestones are a lumachelle, some of them being entirely composed of *Ostrea acuminata* cemented together.*

Palæontological Features of the Typical Fuller's-Earth.—The Fuller's-Earth does not possess a special fauna, and though regarded usually sterile as to the number of species, yet it is characterized by the profusion of *Ostrea acuminata*, *Terebratula ornithocephala*, and *Rhynchonella varians.* Professor Ramsay † summarizes the species of the Fuller's-Earth as follows:—Echinodermata 1, Conchifera 17, Brachiopoda 4. Total species 22, and remarks thereon:—"The majority of the forms that passed upwards from the Inferior Oolite limestone seem to have fled the muddy bottom of the Fuller's-Earth sea, and to have returned to the same area when the later period of the great oolite began .The Fuller's-Earth may be considered only as a comparatively unfossiliferous and inconstant lower zone of the Great Oolite." The inference stated in the first sentence of the quotation is not consonant with facts; for in the first place that portion of the Inferior Oolite which has furnished the larger proportion of Great Oolite species, and indicates similar conditions of deposition, is that of lower freestone beds and pea grit of Cheltenham, which occupy the base of the Inferior Oolite,‡ and in the second place, of the species common to the Inferior Oolite and Great Oolite, those which appear in the later stages of the former formation, occur also in the Fuller's-Earth. The second sentence of the above quotation is no longer applicable, inasmuch as though the fauna of the Fuller's-Earth is not exceedingly rich, yet far exceeds in number the then catalogued species, and, as I shall endeavour to show, has a greater affinity to the Inferior Oolite than to the Great Oolite.

The number of species catalogued by me from the Fuller's-Earth is 93, distributed in the following classes:—

Zoantharia	3	Gasteropoda	4
Annelida	4	Cephalopoda	10
Echinodermata	10		—
Brachiopoda	10	Total ..	93
Conchifera	52		—

So that the Fuller's-Earth is not so barren in species as is generally supposed. Of the 93 recorded species, two, *Montlivaltia tenuilamellosa* and *Belemnites parallelus*, have not been found in any other formation; and respecting the range of *Myacites Terquemus*, Buv, and *Pholadomya truncata*, Buckman, I have no information; 6 forms are at present undetermined, whilst the bulk of the species, 81, occur in either the Inferior Oolite or Great Oolite, or in both formations.

---

* Hull, Mem. Geol. Surv., sheet 34, p. 11.

† Anniversary Address Geol. Soc., 1864.

‡ See Lycett Cotteswold Club, vol. i., p. 71 et seq.; and Wright, Q. J. G. S., vol. xvi., p. 11.

The range of the 84 determined species is as follows:—

Peculiar to the formation	2
Common to the inferior oolite and Fuller's-Earth	33
" " great oolite " "	13
" " three formations	36

Accordingly, 69 species, or 83 per cent., occur in the Inferior Oolite, and 49 only, or 60 per cent., are found in the Great Oolite or superior formations. These results lead us to the inevitable conclusion, that the Fuller's-Earth is a subordinate member to the Inferior Oolite rather than to the Great Oolite, as hitherto considered.

The Inferior Oolite presents in its organic remains at least a twofold aspect, and whilst the older fauna is to some extent repeated in the Great Oolite, the newer fauna lived on during the deposition of the Fuller's-Earth, but did not extend into the Great Oolite. Indeed, the majority of the species common to the Fuller's-Earth and the Inferior Oolite made their appearance in time in the upper zones of the Inferior Oolite; such are:—*Serpula tetragona, Holectypus depressus, Hyboclypus gibberulus, Clypeus Plotti, C. Hugii, Echinobrissus clunicularis, Waldheimia ornithocephala, Terebratula perovalis, T. globata, Rhynchonella varians, R. spinosa, Cypricardia Bathonica, Ceromya Bajociana, C. striata, Goniomya angulifera, Isocardia nitida, Mytilus Sowerbyanus, Ostrea acuminata, Pleuromya æquata, Pholadomya Heraulti, Ammonites Parkinsoni, A. discus*, &c., &c.

And so close is the affinity subsisting between the fauna of the zone of *Ammonites Parkinsoni* and the Fuller's-Earth, that massing the species of these two horizons, the contrast in their numerical relations to those of the lower zones of the Inferior Oolite is as great as that which they present to those of the Great Oolite.

In conclusion, the Fuller's-Earth is not a *formation*, but only the uppermost, or a fourth, zone of the Inferior Oolite. Here, there is a marked decadence of Inferior Oolite species, yet at the same time the facies is decidedly after that fauna.

NOTICES OF SCIENTIFIC WORKS.

WROUGHT-IRON BRIDGES AND ROOFS.*

Of all materials used in construction in these days of progress, there is none which plays so important a part in engineering and architectural art as iron. This material has become the only resource of the engineer for carrying out those large designs and projects which thirty years ago would have been considered chimerical. The attempt to cross the Menai and Conway Straits with bridges formed of wrought-iron plates was treated by mathematicians and engineers as they would have regarded a chapter in the 'Arabian Nights;' and more than one eminent mathematician pronounced the attempt—however ingenious the combinations might be in the shape of iron plates—as a wild and fabulous scheme. It was only those connected with the preliminary experiments—which led to the form and principle of construction—who could form a correct idea of the project and establish with certainty the principle on which those important structures were founded.

It must be admitted that the position of the load and the form of its distribution were not attended to with the same mathematical accuracy as at the present day; but the general dimensions, extent of span, and weight of load were carefully considered, in order to resist every possible strain and to render the structures secure. All this was done in the face of detractors, and the doubts and fears of men of science, and the results are the completion of the Britannia and Conway Tubular Bridges, as they now exist, as firm and secure as the first day they were opened for public traffic. It is true that tubular bridges, such as the Britannia and Conway, are of a more expensive type than those subsequently introduced; but although extended practice and the progress of science may have suggested improvements, it cannot be disputed that all subsequent constructions of this kind are founded on the same principles as those to which we may safely refer as the pioneers of all their successors. We have a much greater variety in the forms of wrought-iron bridges now than when first introduced; but the principle, so clearly exemplified in the Britannia and Conway Tubular Bridges, is identical with more recent constructions in the balance of the two resisting forces of tension and compression, as exhibited in the upper and lower sides or flanges of those important structures.

---

* 'Wrought-iron Bridges and Roofs:' Lectures delivered at the Royal Engineer Establishment, Chatham. By W. Cawthorne Unwin, B.Sc. Associate Inst. C.E. E. & F. N. Spon.

Wrought-iron girders, whether tubular, plate, or lattice, are therefore simply modifications of what has already been done in the same direction, and provided careful attention is given to the quality of the material and soundness of the workmanship, we may rest assured of the security and permanence of every similar structure.

Many distinguished men of science have written treatises to elucidate the principles involved in the tubular and girder constructions, and among them may be mentioned Mr. Unwin, who has just published a report of his lectures on this subject, including a short treatise on the construction of iron roofs, delivered to the members of the Ordnance Corps at Chatham. As a lecturer on practical science a more efficient person could probably not have been selected, for—to a competent knowledge of mathematics applied to constructions—Mr. Unwin has had the advantage of five years' practical experience with Sir William Fairbairn of Manchester, and he therefore enters upon the discussion with a full knowledge of the subject on which he treats.

In the first lecture Mr. Unwin fully proves the advantages he has gained, by the competency with which he enters upon the investigation of stress and strain, bringing to his aid many apt illustrations, and by the graphic way in which he treats the principles of load and molecular resistances, greatly for the benefit of the student and those interested in the accuracy of iron constructions. To show the distinction between stress and strain, which means the force of the former applied to a material body, and the alteration or the resistance of the latter as a result, Mr. Unwin states, that the "strain is sensibly proportional to the stress for a range of about only one-third of the whole stress which may be applied before rupture ensues, if the bar has not previously been strained, and for a range of, perhaps, two-thirds of the breaking-stress, if the bar has not previously been loaded with nearly the whole breaking-weight. But in either case, with loads near the breaking-weight, the strain is not proportional to the stress, and the condition of perfect elasticity is not fulfilled. Hence laws derived from the consideration of a perfectly elastic material will not give accurately the ultimate resistance of structures of wrought iron."

The second lecture is devoted to the intensity of stress on bridges, and the methods of estimating the load and its limits of safety. It also relates to the weight of the structure and its load, or the dead weight and its live or rolling load. In this, as in the former lecture, Mr. Unwin gives some useful examples and illustrations of highly practical value to the student and engineer.

The third lecture treats of tubular, tubular-girder, and plate-girder bridges, showing the ratio of the top and bottom flanges to span, the depth of girder to span, and the method of designing, &c.

Lectures IV. and V. contain comparative examples of the Warren, lattice, and other kinds of bridges; showing also the direction of the strains of the lattice as compared with the solid web connecting the upper and lower flanges of the plate bridge. In this part of the investigation the author seems to demonstrate the theoretical advantages of the lattice or open web over that of the solid plate-girder, since in that system the bars may be inclined to the direction of the strains of tension and compression, which is not the case in the plate-web. There are, however, compensating advantages in the solid plate-web which appear to have escaped the author's notice in the increased degree of stiffness which is obtained in both the plate and the box girders. Many examples of this kind may be shown in bridges of long and short spans, and probably one of the best and most substantial of this sort is that over the Lune at Lancaster. The advocates for the open-web system have intimated the saving of weight at 50 per cent., but that statement is out of all question, as the only saving is in the difference between the open bars connecting the upper and the lower flanges in the lattice-girder, and the middle web connecting the flanges in the plate-girder, and which in the very best iron construction of that description is much nearer 6 or 7 per cent., and in some cases the difference is inappreciable.

The question of joints has been fully discussed by many writers; but the author brings under the notice of engineers the different modes of rivetting, and, without entering upon the merits of punched and drilled holes, he gives a mathematical analysis of the different processes which enter into the maximum strengths and forms of rivetted joints.

On Roofs.—Lecture VI.—Mr. Unwin states that "in the supporting framework of roofs precisely the same mechanical problem is presented as when a railway or roadway is to be carried over a ravine or river. Hence it is that the successive combinations adopted for bridges reappear, in essentially the same forms, as roof principals. The stone-vaulted inner roofs of some of the older churches are structurally identical with masonry bridges. Timber roof-trusses are simply awkward-shaped girders, or, like the great roofs at King's Cross and over the transept of the first International Exhibition, they are timber arches analogous to those frequently erected as bridges in the earlier history of railways. Nor is the case otherwise with iron. All iron roofs may be classed as girders or as arches, with certain transitional forms which embody the features of both classes. And to pursue the analogy farther, even the suspension principle, which at first sight, from the nature of the supports required, would seem inapplicable to the purpose, is, according to a proposal of MM. Lehaitre and De Montdesir, to be pressed into the service of the roof-builder."

Of the construction of roofs many examples are given, and the strains on the parts of different forms are carefully worked out in spans varying from 15 to 240 feet. The methods of determining the strains for differently formed roofs are exceedingly well adapted for obtaining perfect security, and the clear and distinct manner in which the subject is treated must be highly edifying to the student and practical engineer.

We might enlarge on this, but it could not be expected that a subject of such importance as Iron Roofs and Bridges could be successfully treated within the limits of a few lectures. There is, however, sufficient matter contained in the work before us to recommend its perusal to the consideration of the practical architect and engineer; and looking at the clear and graphic style in which it is written, we feel indebted to the author for this addition to our knowledge of practical science.

Habit and Intelligence, in their connection with the Laws of Matter and Force: a Series of Scientific Essays. By Joseph John Murphy. 2 vols. London: Macmillan & Co., 1869.

The intricate problems of the genesis of animal and vegetable life, and of the connection between the human mind and its material abode, will ever be among those which engage and fascinate our intellects of the highest order. The doctrine of a gradual evolution of life, as opposed to that of distinct specific creations, with which the great name of Darwin is associated, and which has been elaborated by Spencer, Wallace, and Hooker, has of late years received an extraordinary impulse; while the parallel theory of a "physical basis of life" has obtained the sanction of some of the highest names in natural science. While these theories are doubtless founded on a substratum of truth unknown to our older naturalists, they are probably mixed up with a considerable amount of error and over-statement, which further investigations will remove. We therefore cordially welcome a work in which the problems of organic life are treated with so free and independent a hand, and with such close reasoning applied to a wide knowledge of facts, as we find in the volumes before us. While adopting the view of the evolution of all living organisms by descent, with modifications, from a few, if not from a single germ, Mr. Murphy holds that the Darwinian theory of Natural Selection from spontaneous variations is inadequate to account for the major part of these modifications, and altogether rejects the Huxleyan principle that the phenomena of life can be accounted for and explained on purely physical principles.

The first volume of this series of Essays is occupied with a consideration of the laws which govern the material world, and a comparison of them with what we know of those which prevail in the domain of organic life. With great acuteness and force of illustration, Mr. Murphy points out that while it is a feasible hypothesis that many of the structures which we see in the animal and vegetable worlds are attributable to Natural Selection, or "the Survival of the Fittest," acting through a long course of generations, there are others which it is impossible to conceive can have become developed through the operation of this law, or of that promulgated by Herbert Spencer, depending on the mechanical adaptation of structure to function by the force of external agency. To this category belong such organisms in the vegetable kingdom as the hard, woody shell that protects the nut, but still more conspicuously all the most complex organs of the higher orders of animals. We will give the argument in Mr. Murphy's own words:—

"There are structures for the origin of which it is, I believe, utterly impossible to account by any merely physical theory. I refer to such organs as the eye and the ear. If it is certain, as I think it is, that the flow of the nutritive fluids through cellular tissue, for successive generations, must have a tendency to form a rudimentary circulating apparatus, it is at least equally obvious that the action of light falling on the eye for any number of generations, can have no similar tendency to produce the optical apparatus of the eye. Nor can the constant exercise of the eye in the act of seeing have any such effect. The exercise of the eye, within the limits of what is healthful, does, no doubt, tend to increase the sensitiveness of the retina; and I do not say it is impossible, though I do not admit it as probable, that the muscular arrangements to which the mobility of the eyeballs and eyelids is due, may have been produced by the effort to move them, continued through successive generations; and that the expansion of nerves over the retina may have been produced by the constant stimulation of the nerves themselves. But no such merely physical theory will account for the origin of the special complexities of the visual apparatus. Neither the action of light on the eye, nor the actions of the eye itself, can have the slightest tendency to produce the wondrously complex histological structure of the retina; nor to form the transparent humours of the eye into lenses; nor to produce the deposit of black pigment that absorbs the stray rays which would otherwise hinder clear vision; nor to produce the iris, and endow it with the power of partly closing under a strong light so as to protect the retina, and expanding again when the light is withdrawn; nor to give the iris its two nervous convexions, of which one has its root in the sympathetic ganglia, and causes expansion, while the other has its root in the brain, and causes contraction."

Admitting, then, as Mr. Murphy does, the premiss of the common ancestry of all organisms, by what process is it possible to account for the gradual evolution of a being with so complex an organ as an eye from the primordial homogeneous and amorphous *Amœba* or *Gromia?* He sees the explanation in the co-existence with the vital principle of an Organizing Intelligence, consciously present in the mind of man, unconsciously in all organized structure. He believes that "the wondrous fact of organic adaptation cannot have been produced by any natural selection, or by any unintelligent agency whatever;" that "wherever there is life there is intelligence, and that intelligence is at work in every vital process whatever, but most discernibly in the highest." The recognition of this Organizing Intelligence running throughout organic nature, is the keystone of Mr. Murphy's system. The unconscious intelligence by which the bee stores up food for the sustenance of the larvæ, and builds cells for its reception on mathematical principles, is the same principle as the unconscious intelligence which has given it the organs necessary to collect the honey; the conscious intelligence in the mind of man which has manufactured the microscope is the same principle as the unconscious intelligence which in his body has manufactured, or, to coin a word, has "mentefactured" the lenses of the eye. The reasoning that the eye cannot have been produced by the action of mere natural selection is strengthened by the forcible argument that this latter view presupposes that the same selection from a long series of *spontaneous* variations has taken place in three separate lines of descent, in the Annulosa, the Mollusca, and the Vertebrata, the higher forms of which can, on no plausible hypothesis, have descended directly from one another, or from a common eye-possessing ancestor. Spencer's theory that all structures have been produced by adaptation to function in the individual aided by natural selection in the generation, is combated by the equally powerful argument that "as we ascend in the scale of nature to higher and higher vital functions, and higher and higher organic forms, we find the relation of cause and effect becoming less traceable by our faculties (though no doubt it exists all through nature); while at the same time the relation of means and purpose becomes at once more traceable and more definite. Nowhere in the universe, as known to us, is the relation of means to purpose more clearly traceable and more perfectly definite than in the organs of special sense in the higher animals, especially in the eye and the ear; and nowhere is it more difficult (I would say, utterly impossible) to assign any physical cause for the facts, than when we inquire by what cause, or by what agency, such wonderful organs have been formed. This truth, that purpose is most clearly discoverable where cause is least so, has not received the attention it deserves."

In his second volume Mr. Murphy enters upon the recondite subjects of Psychology, and especially of the relation of the mind to the physical system and to the vital organization. The same mode of reasoning is applied as to the facts of organic life, and an analogous conclusion is the result. As the phenomena of animal and vegetable life cannot be referred to the operation of Natural Selection, or of any unintelligent agency whatever, so Mr. Murphy maintains that in all mental intelligence there is an element not derived from habit, and not resolvable into any unintelligent force; and is hence at issue with the psychological school represented in this country by Mill, Bain, and H. Spencer. In other words, "life, intelligence, and the moral sense is each incapable of being resolved into anything lower than itself." We cannot follow Mr. Murphy over the oft-trodden ground of the existence or non-existence of Innate Ideas—which he believes to be the inherited experience of the race, the reality of our belief in an external world, the origin of our conceptions of time and space, and other cognate speculations, on some of which he contrives to throw new light; but we wish rather to comment on one portion of his scheme which we take to be erroneous. Mr. Murphy points out clearly the difference between conscious and unconscious Sensation, and between conscious and unconscious Thought, the greater part of our thought being unattended by consciousness; but he often confounds, as we think, between conscious and unconscious Volition. Now we would maintain that nothing in our mental constitution is clearer than that the Will is often, and indeed generally, exercised without any consciousness of its action. The movements of the limbs in walking we presume Mr. Murphy would call, and we think erroneously, consensual action, the result of habit. The motion of the heart, of the eyelids, of the chest in breathing, we hold to be truly either consensual or reflex; and the test we would apply is that they cannot be arrested, or only to a very inconsiderable extent, by the action of the Will. In walking, on the contrary, we can stop at any moment we please; and whatever can be arrested by the Will must have been set in motion by the Will. The view has been held that in the motion of the limbs in walking, a certain storage, as it were, of voluntary action, is set at work at the commencement, which is continually flowing forth at every step without any fresh volition. But this idea, we think, will not bear a careful scrutiny. Take the instance of the slight inclination of the body to one side necessary in turning a corner; this cannot be done without the exercise of the Will, and yet we are perfectly unconscious that any such motion is performed. Or we may illustrate our argument by the familiar example of a flight of steps, say twenty, which we are accustomed daily to descend, and which has been shortened by one step at the bottom of the flight. We all know the unpleasant jerk given to the body by the foot coming into contact with the ground with greater force than was expected. We cannot suppose that an amount of voluntary energy was stored up when we commenced the descent sufficient to carry us down exactly the twenty steps; it is evident that the Will was set in motion to descend the imaginary twentieth step with as much force as it was at the first step. But the best illustration of unconscious voluntary action is perhaps afforded by the motion of the fingers in writing, where the warmest advocate of the theory of habit can hardly maintain that the action is entirely consensual; and the storage of the Will hypothesis is evidently inadequate to account for each separate motion of the fingers, which must require a distinct action of the Will, exercised perfectly unconsciously to ourselves. The lateral motion of the eye-balls, again, which takes place in reading, is one evidently entirely under the control of the Will, and is yet performed with the most perfect unconsciousness.

We appear to have dwelt rather on those points in which we differ from Mr. Murphy than on those in which we agree with him. There is, however, much in these two volumes that will interest every student of Biology and of Psychology, and not a little that must commend itself to the attention of every man of science. Whatever acceptance his views may meet with in the scientific world, it is impossible not to acknowledge the fairness and moderation with which he has brought them forward, and the ability with which he has supported them by logical argument and by a large array of facts.

JEFFREYS' BRITISH CONCHOLOGY.*

From the various reports which have from time to time appeared in these pages, of the dredging expeditions of the author of this work, as well as from the notice of the second volume of a portion of the work itself, which is to be found as far back as in our first volume, our readers will have become well acquainted with the active labours of Mr. Gwyn Jeffreys. The publication of the work has extended over seven years, and all we can attempt to do here is to give a brief outline of its contents.

The first volume deals with "land and fresh-water shells," the remaining four with "marine shells;" but from this it must not be inferred that the author's labours have been confined to the description of shells alone. The book is an excellent and complete treatise on the Natural History of British Mollusca, containing not only accurate descriptions of the various genera and species in their zoological order, but accounts of their British habitat, as well as of their geographical distribution. In addition to these details, the work is rendered interesting by such anecdotes and considerations as are calculated to relieve the tedium of study, and we have here and there incidents concerning the different kinds of molluscs, which form an agreeable diversion from the consideration of their anatomy, the form and colour of their shells, and the divergences of species.

---

* 'British Conchology; or, an Account of the Mollusca which now inhabit the British Isles and the Surrounding Seas.' In 5 volumes (commencing 1862 and ending 1869). Illustrated with coloured and plain plates. By John Gwyn Jeffreys, F.R.S., F.G.S., &c. Van Voorst.

In speaking of Helix aspersa, the author tells us* "they make great havoc in kitchen gardens, and spoil the best wall-fruit. There is, however, some compensation for this mischief: a kind of broth is made from them, and used as a remedy for pulmonary complaints. This kind of snail is occasionally eaten by the French; but it is not held by them in the same estimation as the Apple-Snail. Dr. Gray says that the glassmen at Newcastle, once a-year, have a snail-feast, and that they generally collect the snails themselves in the fields and hedges the Sunday before feast-day."

Nor are the author's considerations on the subject confined either to the scientific or the utilitarian, if feasting on snails can be thus designated. He sometimes soars into the regions of poetry; or, as he calls it, the æsthetical. The snail could never secure a footing on Mount Parnassus, he tells us, but "we may enter the realms of phantasy and we shall find it among those intruders which had to be chased from the cradle of the fairy-queen." Homer did not disdain to use the snail's shell as a helmet for belligerent frogs, in his "mock heroic poem." "The most imposing appearance," the author tells us, "which the animal has made in literature," is to be found in Goethe's "wild vision of the Walpurgis Night," when, on the top of the Harz mountains, "an adventurous and preternaturally sensitive snail," "detected the presence and unmasked the incognito of not less a person than Mephistopheles himself." And the author gives us the quotation, describing the occurrence, which leaves no doubt that the snail must have been very preternaturally sensitive, for it was able to smell out the identity of the Evil One with its tentacles!

However, we do not suppose the author had any intention to press the great German poet into the service of science, so we will let that pass.

The first volume of the work treats, as we have said, of land and fresh-water shells; the second, of the marine molluscs, comprising the Brachiopoda and part of the Conchifera. In the third, the Conchifera are concluded, and the Solenoconchia and part of the Gasteropoda treated. The fourth continues the description of the great group Gasteropoda, which is concluded in the fifth volume, where also an account will be found of the higher molluscs, the Pteropoda and Cephalopoda.

---

* Vol. i., p. 183.

Each volume is accompanied with a beautiful coloured plate as a frontispiece, and numerous well-executed lithographs. It suffices to say that the whole work is produced in Mr. Van Voorst's best style, and will form a valuable addition to his well-known treatises of reference on Natural History.

SCHRAUF'S HANDBOOK OF PRECIOUS STONES.

To any one who is not familiar with the elements of mineralogy, a cabinet of precious stones—however rich and rare—has no more educational value than a collection of shells can have to a person ignorant of the anatomy of the mollusca. Yet it is by no means needful to plunge into the depths of mineralogic lore in order to appreciate the scientific value of a gem. All that is necessary is a moderate acquaintance with the physical and chemical characters of the comparatively few minerals which rank as precious stones, and of those substances which are likely to be mistaken for genuine gems. Dr. Schrauf, of Vienna, has recently published a textbook,* which gives, within a moderate compass, all that mineralogical information which the collector ought to have at hand.

The early chapters of the work are devoted to a discussion of mineralogical physics—a subject which no one can handle better than the author of the elaborate *Lehrbuch der physikalischen Mineralogie.*

Popularly, yet accurately, he tells us all that we need know on the crystalline form of minerals, their hardness, density, thermal, electric, magnetic, and optical properties. Then follows a chapter on the forms in which precious stones are commonly cut by the jeweller. Each gem is then described separately, in order of value, commencing, of course, with the diamond.

In the chapter on Diamond, our author proposes a new formula for determining the value of this stone—a formula which is said to give results coinciding with the present market value of diamonds, and is, moreover, applicable to stones of high weight. Let a denote the current price of *one* carat; then the value of a diamond weighing m carats will be, according to Schrauf's formula,

$$\frac{m}{2}(m+2)\,a.$$

To illustrate the application of this rule, we may calculate the value of the celebrated Sancy diamond, which was sold only a year or two ago, and to which so romantic a history is attached. This diamond is said to weigh about 53 carats, and being only rose-cut, one carat may be valued at 15*l*. Then, according to our rule, the value of the diamond may be thus expressed in pounds:

---

* 'Handbuch der Edelsteinkunde,' von Dr. Albrecht Schrauf. Wien, 1869. Pp. 252.

$$\tfrac{53}{2}\,(53 + 2)\,15 = 26{\cdot}5 \times 55 \times 15 = 21{,}862{\cdot}5.$$

It must be admitted that this is a tolerably near approximation to the true value, when it is stated that the diamond was sold by Prince Demidoff to Sir Jamsetjee Jejeebhoy for 20,000*l*.

Perhaps the most useful part of this work is to be found in the concluding chapters, which explain the method of determining an unknown gem, the results of which are afterwards collected in a tabular form.

We shall be glad to see so excellent a work as this translated into English.

SENFT'S MINERALOGY AND LITHOLOGY.*

IF one branch of natural science, more than another, deserves to find a place in any improved scheme of scholastic education, that science, according to Dr. Senft, is undoubtedly Mineralogy. For, apart from its practical value to all whose daily occupation brings them into contact, directly or indirectly, with the products of the mineral kingdom—such as the miner, the builder, the agriculturist, and the manufacturing chemist—the study of mineralogy is so closely connected with that of many collateral sciences that a course of mineralogical lectures, properly delivered, might be made the means of imparting to a class much valuable information on the sciences of chemistry, physics, and geology, to say nothing of solid geometry. Hitherto this relation of mineralogy to other branches of science has been regarded as a great stumbling-block to the student, inasmuch as he must needs acquire a rather wide range of knowledge before he can successfully cope with the difficulties of mineralogy. These difficulties may, however, be removed, to a great extent, by an attractive style of instruction, adapted to the capacity of the pupil, but at the same time not superficial enough to nullify the efficiency of mineralogical study as a means of intellectual training. Five-and-twenty years' experience in teaching science to youths between fourteen and sixteen years of age, has led our author to mature a scheme of instruction which he regards as best adapted to meet the wants of those who may not wish to push their mineralogical studies beyond a very moderate acquaintance with the more important species. He devotes to this study only two hours weekly, but he extends the course over two years. The first year's course is only preparatory, and chiefly chemical. The student first learns the properties of the elements, and thus becomes, to some extent, acquainted with the characters of such species as the diamond, graphite, sulphur, and the native metals. He then advances to the study of simple chemical combinations, and is thus made acquainted with the chief acids and metallic oxides. This chemical course occupies a summer session, and is followed, during the succeeding winter course, by the study of the physical properties of minerals, as demonstrated on certain species of simple composition. Our author's mode of teaching may be illustrated by an example of his lesson on Quartz. A piece of common quartz is exhibited to the class, pulverized, and treated successively with water and the ordinary acids, for the purpose of showing its insolubility in these reagents. A small quantity is then mixed with an alkaline carbonate, and slowly heated for a quarter of an hour in an iron capsule. The effervescence consequent on the expulsion of the carbonic gas points to the acid character of silica; while the formation of a vitreous silicate illustrates the chemical composition of glass. During these experiments, an apt teacher will, of course, entertain his class by a valuable lesson on the manufacture of glass, and by explaining the method pursued in the analysis of siliceous minerals. Having thus become familiar with the chemical characters of the species, a well-formed piece of rock-crystal is exhibited to illustrate its crystalline form. The six-sided prism and its two terminal pyramids furnish a text for much instruction on the crystallography of the hexagonal system, whilst models of the forms are made in clay before the class, or, still better, by the students themselves. Attention is then directed to the other physical properties of quartz: its hardness is shown by its resistance to the knife, and by striking sparks with steel; its specific gravity is taken; its phosphorescence exhibited; and electricity is developed by friction. In this way the student becomes interested in chemical and physical science; and if no other scientific study be introduced into a system of general education, much solid instruction can be imparted by a judicious study of our common minerals.

---

* Lehrbuch der Mineralien und Felsartenkunde. Von Dr. Ferdinand Senft 8vo. Jena, 1869. Pp. 656.

The second year's course comprehends work of a more strictly scientific character, and includes the principles of classification and a description of the more important mineralogical species.

To supply a work adapted for instruction of this practical kind, Dr. Senft has prepared a useful Text-book of Mineralogy and Lithology. The first part is devoted to the general principles of mineralogy; the second, to a description of the principal species; and the third, to the study of rocks or aggregates of minerals. In the notice of species those only are described which have acquired importance by their wide distribution, by their applications in the arts, or by their functions as rock-constituents. A few rare species are, indeed, described, but only on account of certain marked peculiarities, either physical or chemical. Two plates of crystalline forms bring the work to a conclusion.

Vegetable Teratology: an Account of the Principal Deviations from the usual Construction of Plants. By MAXWELL T. MASTERS, M.D., F.L.S. London: Published for the Ray Society, 1869.

THE attention which Dr. Masters has for many years bestowed on abnormal developments of the various organs of plants, renders this last publication of the Ray Society from his pen a peculiarly valuable one. The importance of a study of teratology, both to the morphological and to the systematic botanist, in determining not only the true relationship of organs to one another, but the structural position of difficult orders, has only recently been acknowledged. Moquin-Tandon's has been heretofore the standard work on the subject, but is completely out of date in the light of modern research; since his time St. Hilaire, Morren, and others have investigated the subject; but up to the present time nothing of importance has appeared in this country, except a very old treatise by Hopkirk.

The classification of a number of facts necessarily so unconnected with one another as monstrosities and irregular growths presents considerable difficulties; in our present imperfect state of knowledge of the causes of these variations from typical structure, we think Dr. Masters has done wisely in adopting in the main Moquin-Tandon's somewhat empirical arrangement, rather than attempting one with more claims to a philosophical basis. He arranges the phenomena under four heads:—1st. Deviations from ordinary arrangement, including union or independence of organs and alterations of position; 2nd. Deviations from ordinary form; 3rd. Deviations from ordinary number, whether increased or diminished; and 4th. Deviations from ordinary size and consistence, including hypertrophy and atrophy. Under any classification a certain amount of repetition is unavoidable; but is probably as small under the one here adopted as could reasonably be expected.

The work does not profess to be a philosophical treatise on the causes of aberration from typical form, but rather a chronicle of the most important instances which have come under the notice of the writer himself and of other observers; and the immense variety of these deviations from the usual construction of plants must astonish the casual observer. We have well-authenticated examples, for instance, not only of the comparatively common transformation of sepals into petals, or of complete suppression of the calyx or corolla; but of the far rarer production of ovules within the anthers, in the case of a *Cucurbita*, and of pollen within the ovules in the instance of a passion-flower. Scarcely less curious is the formation of a flower-bud within the pod in the charlock, and of a miniature siliqua in the place of a seed in the wall-flower. Of greater practical importance than these strange abortions, are the minor irregularities in the less vital organs, constituting the possible origin of new races that have obtained predominance in the "struggle for existence." To the physiologist who devotes himself to the investigation of the causes which lead to the production of abnormal forms, and of their connection with the origin of species, Dr. Masters's volume will be an invaluable repertory of facts. We cannot too highly commend the care with which the innumerable instances that must have come before him have been sifted, and those selected which are undoubtedly authentic, and which may be considered as typical; or the labour which has been bestowed on the bibliography of the subject, consisting mainly of separate articles and descriptions in the various English and foreign botanical magazines, collated under the different heads into which the book is divided. The volume is illustrated with upwards of 200 capital drawings by E. M. Williams; many of the best of which have already appeared in the pages of the 'Gardener's Chronicle' and other publications. We are glad to hear that a translation of the work into French is already arranged.

Cyclopædic Science Simplified. By J. H. Pepper. London: F. Warne and Co., 1869.

Professor Pepper has not only distinguished himself by the eminently practical way in which he has converted the Polytechnic Institution from a losing to a paying speculation, by discovering the proper combination of electricity, conjuring, dissolving views, chemistry, ghosts, and comic songs—a sort of scientific Punch, in fact—which draws the largest audiences; but he has brought the same talents to bear upon literature, and has given to the world, at intervals, three books—'The Play Book of Science,' 'The Play Book of Metals,' and the one now under our notice. Looking at these books from a highly scientific stand-point, we have no doubt much fault might be found with each of them; but from the point of view of that large section of the public whom Professor Pepper addresses, it would be difficult to say how they could be greatly improved. The present book embraces Light, Heat, Electricity, Magnetism, Pneumatics, Acoustics, and Chemistry. In each of these subjects, a large amount of information, generally of the newest character, is given; the original papers on the various subjects as read before the learned societies being copiously quoted. As the author is almost bound, he gives full details of the various illusions and scientific tricks, ghostly and tangible, which have tended so much to popularize the Institution with which he is connected. The illustrations are numerous, and valuable in many cases, possessing an interest to men of the highest attainments in their respective spheres; and the initial engravings to the chapters are in many cases portraits of eminent philosophers. Thus, on page 197 we have James Watt, with autograph; at 392 is one of the best portraits we have ever seen of Sir Charles Wheatstone; on page 527 is an excellent portrait of Faraday; and at page 578 is one of Sir David Brewster. In addition to these, there are over 530 woodcuts, some of most elaborate description, and a chromolithograph as frontispiece, in which the author is exhibiting to an astonished audience the wonders of spectrum analysis, on a scale of magnitude never before witnessed.

Taking all things into consideration, we have no hesitation in saying that 'Cyclopædic Science' is one of the best books for boys we have ever met with. Its intrinsic attractiveness will do much to give a taste for science, and lead to a spirit of inquiry which will not be satisfied until the young philosopher possesses an experimental laboratory of his own.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

---

1. AGRICULTURE.

The past three months have bristled all over with topics of agricultural interest—many of them, unfortunately, involving disagreeable experience. It is certain, now that a large portion of the wheat crop has been threshed, that the harvest of 1869 has been very much below the average productiveness of past years: and the low prices which wheat commands, owing probably to no one wanting corn in the general market of the world except ourselves, whatever their benefit to the nation at large, have materially aggravated to English farmers the injury of a deficient yield.—The foot and mouth disease—a cattle plague of more or less virulence and frequency ever since 1839, when it first appeared—has been unusually general and severe during the past autumn. It is now, however, believed to be on the decline. Though rarely fatal, it is a painful malady, stopping the milk of cows and wasting the flesh of fatting cattle, and thus destroying the property of stock owners. It is generally supposed to be an importation from the Continent; but though that probably was true thirty years ago, it can now hardly be doubted that the disease has become indigenous. Careful quarantine, both at the ports of debarkation, and in home localities wherever it exists, has, however, all along been urgently demanded, and it has been at length conceded, so that we may hope to see the evil reduced within less serious limits.—The miseries of cattle transit, whether by land or by sea, have been urged on public attention, especially by the interest which Miss Burdett Coutts has taken in the subject. The use of a railway cattle-truck, in which live stock shall have access to both food and water on a long journey, is most desirable; and it is believed that the inferior condition in which cattle after a railway journey reach the metropolitan market from great distances, when they have had no refreshment on the road, must at length make consigners of such cattle willing to pay the expenses involved in the provision of better accommodation. An experiment directed by Miss Coutts, in which six cattle were sent from Edinburgh to London, shows that cattle will eat and drink upon the way with great comfort to themselves and great advantage to their owners, if they have the opportunity.—The condition of Ireland, which is to a great extent an agricultural question, has of late occupied the public mind more painfully than any other topic. Among the most valuable and suggestive of the many pamphlets which have been lately published on this subject is one by Mr. James Caird, in which he insists upon the curative influence of the lease of land for a term of years, as that which by its proved effect elsewhere is more likely than any other agency within our reach to be serviceable in Ireland. The Lothians of Scotland, which are the very model farm of British agriculture, were a century ago as badly off as Ireland is at present. Since 1780, owing chiefly to "enabling laws" affecting the condition of strictly entailed estates, the principle has become established, and the practice has become universal there, that the duty of the landlord is to provide the farm with buildings and other permanent improvements, and that the duty of the tenant is to find the capital for cultivation under the security of a lease for a fixed term of years. It is the influence of the lease for a term of years that has been so wonderfully illustrated in Scotland; and Mr. Caird would accordingly confine all Government assistance in land-improvement to estates and farms let on lease; and in other ways he would urge on Irish landlords and Irish tenants the acceptance of the lease, certain that it would create fertility and ensure industry and promote contentment in Ireland, as it has elsewhere.—A very striking picture of foreign agriculture has been drawn by Mr. James Howard, M.P., in a lecture before the London Farmers' Club. He has proved conclusively that the small-farm system prevalent in many continental countries is greatly inferior to our own plan of large holdings in almost every particular in which they admit of comparison. In the actual maintenance of a large population directly on the land we presume the former must be acknowledged superior; but the condition of both occupier and owner under such circumstances is shown to be below that of the English farm-labourer, while the labouring class in such a case are in a miserable plight indeed. The small-farm system, and still more the small-estate system, may possibly be defensible on other grounds of state policy, but for its power to turn the soil to the most useful account; and for its power, or rather want of power, to "stock" the country with an intelligent middle-class population, it admits of no defence. Mr. Howard's excellent paper is indeed a sufficiently convincing proof that English agriculture, in spite of our higher northern latitude, is on the whole more productive than that of such districts as he had visited; and that taking even Belgian farming with which to compare it, and with which it has been occasionally contrasted to its discredit, the agriculture of our country is on the whole superior, whether as to its produce of grain and of meat or as to its maintenance of an intelligent and well-conditioned tenantry.—The condition of the English agricultural labourer has lately occupied the attention of several Farmers' Clubs, and it seems proved that the mere labourer in the country is on the whole better off than the mere labourer in town. The summary of the 'Agricultural Gazette' on the subject may be adopted as on the whole trustworthy:—

"Probably the safest conclusion at which an outsider, patiently considering the various allegations, can arrive, may be stated thus:—Both in country and in town great poverty and great misery exist; both in country and in town the provident and well-conducted man is able to rise in his position; whether in country or in town, there is no help, even for the 'helpless' classes, that can approach *self-help* for its power and efficiency. In the worst-paid agricultural districts the young unmarried agricultural labourer has plenty of pocket-money. He can squander it and acquire habits which will render comfort in after-life impossible, whatever be his earnings; or he can save it, and begin life with a good character, a houseful of furniture of his own, and the best girl in the parish for his wife.

"The possibilities of the agricultural labourer, whether for decent comfort or for utter misery, are at least equal to those of the corresponding class in town. And we feel sure that any considerate master who by the interest which he takes in the lads and young men upon his farm, shall retain them in his service, and thus keep them from the chances of town life, will at least have done them no harm. Paying them as much as possible according to their work, *i.e.* 'by the piece,' and interfering successfully by friendly advice in the alternative before them of saving or of wasting wages in their youth, he will have secured for them a place in the higher division of a class which contains a large proportion of individuals living in comfort and respectability."

The beet-sugar manufacture is prospering. Mr. Duncan's factory at Lavenham is answering his purpose, and it is also answering the purpose of the growers of sugar beet in that neighbourhood, so that in all probability we have at length secured the establishment among us of a new industry, from which, judging by its effect in agricultural districts of France and Germany, the best consequences may be anticipated.—The results of the application of sewage manure to land have been reported at Lodge Farm, near Barking, and elsewhere, as having been this year satisfactory. It is impossible to doubt that this subject will soon rank with the very foremost in agricultural and social importance.

2. ARCHÆOLOGY (Pre-historic),

And Notices of Recent Archæological Works.

In vol. v. (No. xx.), p. 546, Oct. 1868, we gave a short account of the meeting of the International Congress of Pre-historic Archæology at Norwich. The papers read at that meeting have since been published, and now form a handsome volume, well illustrated by fifty-three plates and numerous woodcuts.* It would be difficult to estimate the relative value of the contents of this volume, but one paper which, to us, appears a singularly important communication is by Mr. George Busk, "On the Caves of Gibraltar in which Human Remains and Works of Art have been found." This contribution, which is illustrated by twelve plates, maps, and plans, contains the most complete record yet published of those interesting limestone caves and fissures for which the Rock of Gibraltar is celebrated, but which, till lately, only served to gratify curiosity, or, by their illumination, to eke out the scanty amusements of an almost isolated garrison.

It was to the investigation of these caverns that the last efforts of the late Dr. Hugh Falconer's life were directed, in conjunction with Mr. Busk, the work being carried out upon the spot by Captain Frederic Brome, late governor of the military prison at Gibraltar, whose unwearied labours during the last five or six years have been devoted to their exploration.

The rocky peninsula of Gibraltar is a detached promontory, composed principally of limestone, about three miles long and three-quarters of a mile in its greatest width, and lies nearly due north and south. The lower portion of the western side spreads out so as to form an irregular sloping surface, here and there interrupted by longitudinal cliffs and ravines, upon the gentle declivities of which the principal part of the town of Gibraltar is built.

The eastern face, on the contrary, is a nearly perpendicular escarpment of limestone rock rising up at 'Wolf's Crag,' or 'North Front,' in a cliff 1250 feet high; at the 'Signal Station,' or 'Middle Hill,' 1255 feet; and at 'Sugar-loaf Hill,' on which O'Hara's Tower stands, it rises to a height of 1408 feet above the sea. A broad plain extends beneath 'Sugar-loaf Hill' to the south, called 'Windmill Hill Flats,' whilst at a still lower level 'Europa Flats' form the southern termination of the promontory. The mass of the rock consists of a Secondary Limestone of Jurassic age, much fissured and dislocated, and dipping to the west, but towards the southern extremity the beds become nearly vertical.

---

* 'International Congress of Pre-historic Archæology: Transactions of the Third Session, opened at Norwich, 20th August, and closed in London, 28th August, 1868.' London: Longmans, Green, & Co. 1869. 8vo. Pp. 419. Illustrated with numerous plates and woodcuts.

As is well known, *caves* constitute a prevailing feature of limestone rocks in all parts of the world, and in no place are they more numerous within a similar compass than in the promontory of Gibraltar, which has, in fact, on that account sometimes been termed the 'Hill of Caves.'

The caves are of two kinds. 1. *Littoral or sea-caves,* scooped out horizontally by the waves at the sea-level; of which kind there are numerous instances all along the base of the eastern face; successive terraces, one above another, are also visible on the same face, each furnished with its line of sea-caves, exactly like those at present at the level of the water. It would seem, however, that most, if not all, of these caves owe their origin to their being situated in the line of a fissure or fracture of the rock of which the sea has taken advantage to begin its scooping action. 2. *Inland caves,* which do not exhibit any appearance of marine erosion, but may be described as ramified and intersecting fissures, descending more or less vertically to great depths, and enlarged by the action of rain-water charged with carbonic acid.

The principal littoral or sea-caves are:—

'Martin's' and 'Fig-tree' caves, 700 feet above the sea, in the eastern face of the rock below O'Hara's Tower; some caves just above the blown sands in Catalan Bay; 'Monkey Cave,' 100 feet above the sea; 'Beefsteak Cave,' in the cliff below Europa plateau; 'Genista Cave,' No. 4, 40 feet below the top of the eastern cliff of Windmill Hill plateau; 'Poca Roca Cave,' in the western face of the northern end of the rock; besides many smaller caves in the eastern face.

The principal fissure-caves are:—

The famed 'St. Michael's Cave,' opening to the west, situated in the southern portion of the rock, at an elevation of 1100 feet above the sea; the 'Genista Caves,' Nos. 1, 2, and 3, all situated in the Windmill Hill plateau, where there is also a deep ossiferous fissure.

The four Genista Caves, Martin's Cave, St. Michael's Cave, and some others, have yielded evidences of early man, in the form of osseous remains associated with flint knives and flakes, stone axes, polished and chipped; worked bones, serving as skewers, arrow-heads, needles, and gouges; anklets or armlets of shell, hand-made pottery, querns, rubbing-stones, and charcoal. With these were found remains of numerous animals,* including:— *Rhinoceros*

---

* [Those marked thus §, are abundant; and thus §§, very abundant.] A single molar of *Elephas antiquus* was obtained many years since by the late Mr. James Smith, of Jordan Hill, in an old sea-beach (now demolished) at Europa Point, the southern extremity of the rock.

etruscus, *Rh. leptorhinus*§ (extinct); *Equus*, *Sus priscus* (extinct); *Sus scrofa*, *Cervus elaphus*, var. *barbarus*§, *Cervus dama*§, *Bos* (a large form), and *Bos taurus*§. Two forms of Ibex, *Capra Ægoceros*§§; and also the common goat, *Capra hircus*; *Lepus timidus*, *Lepus cuniculus*§§, *Mus rattus*. Of the carnivora were determined *Felis leopardus*, *Felis pardina*, *Felis serval*, *Hyæna brunnea*, *Canis vulpes*, *Ursus* sp. Remains of the common dolphin, numerous genera and species of birds, a species of tortoise, and numerous remains of fishes, of which the tunny is most prominent.

The remains are imbedded in red cave-earth, and also in a black layer similar to that noticed in the caves of France and elsewhere. In many instances the organic remains have been carried down from one cavern to another at a lower level through long fissures, by the heavy autumnal floods which pour from the higher grounds down upon Windmill Hill plateau (where many of these ossiferous caves are situated), bringing with them the remains of the various animals which at an earlier period inhabited the thickly-wooded heights, now entirely destitute of trees and only covered at places by the little *Chamærops humilis*.

Many human and animal remains attributable to modern periods have been also met with; but the older human remains are distinguished by peculiarities in the thigh-bones, which closely resemble those met with in the Cro-Magnon Cave.[*]

Mr. Boyd Dawkins gives a *résumé* of what is known on the subject of 'The Antiquity of the Iron Mines of the Weald.'[†] In the middle of the Wealden formation are two thin bands of ironstone, from which all the iron was obtained. The mines are scattered throughout the district: the method was to sink a shaft through the superincumbent clay to the ironstone, and remove as much ore as was within reach; then fill up and sink again a little farther on, so that the shafts lie very close together. They vary in depth from about 7 or 8 to 40 feet, and in diameter from 3 to 6 feet. The first historical notice is in a grant of Henry III. to the town of Lewes; but Samian and other Roman ware, bronze fibulæ, coins of Nero, Vespasian, &c., having been found at several localities scattered amongst the scoriæ at depths varying from 2 to 10 feet, tend to show that they were worked during the Roman period. These Roman remains were associated with flint flakes and rude unturned pottery identical with that termed Keltic, in some places, and in others alone, which, together with the passage in Cæsar's 'Commentaries' describing the inhabitants of the maritime part of Britain, "utuntur aut ære aut taleis ferreis ad certum pondus examinatis pro nummo. Nascitur ibi . . . . in maritimis ferrum; sed ejus exigua est copia," make Mr. Boyd Dawkins believe that these workings were commenced long previous to the Roman occupation.

---

[*] See our Chronicle of Archæology for July last, p. 411.

[†] Mr. Boyd Dawkins made careful notes of these workings during his stay in the district whilst engaged on the Geological Survey of the Wealden; and he also refers to Mr. Lower's papers in the 'Sussex Archæologia.'

Numerous similar pre-historic iron-mines worked upon the same primitive plan (the product of which, like that of the Fan tribes in Africa at the present day, could only have amounted to a few pounds' weight of metal) are to be met with in many places along the northern part of Norfolk, a little inland, from Cromer to Hunstanton.

The Département de L'Aveyron, to which we referred in our last Chronicle as that in which the Cavern of Bruniquel was situated, seems to be equally rich in megalithic monuments as it undoubtedly is in caves. Of these Dolmens numerous illustrations are given, and also of the ornaments and implements of stone, bone, and bronze found within the mounds and circles.

The Memoir by the Rev. Richard Kirwan, M.A., on the excavation of three Tumuli on Broad Down, Farway, near Honiton, Devon, is of the highest archæological interest, not only on account of the works of art which they contained but also as exhibiting three barrows, each differently constructed, belonging to a very early period, probably long antecedent to the Roman occupation of Britain. Mr. Kirwan's paper is illustrated by nine plates.

There are many other papers in this volume, but we have not space to notice them here.

'Transactions of the Devonshire Association for the Advancement of Science, Literature, and Art, 1869.' 8vo. Pp. 310.—Mr. Pengelly has now published the second part of his 'Literature of Kent's Cavern,' in which he gives the whole of the Rev. J. Mac Enery's manuscript. 'On the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Cavern, Torquay.' The author, in revising the evidence, comes to the conclusion that no remains belonging to the former animal have been found, but that the latter undoubtedly has.

Mr. G. Wareing Ormerod gives a notice of the molars of *Hippopotamus major* stated to have been found in Kent's Cavern, and, like Mr. Pengelly, does not think there is any trustworthy evidence that they were found there.

Mr. Pengelly also contributes a few notes upon the submerged forest at Blackpool, near Dartmouth. This forest, usually entirely concealed by the sand thrown up by the waves, was, for the third time during this century, exposed to view by the tempestuous weather in February last. In the seaward portion was a brownish drab-coloured clay, becoming bluish higher up, thickly covered with vegetable *débris*, trunks of trees varying from 6 inches to 2 feet in diameter, branches, twigs, leaves, and hazel-nuts; no animal or human remains or tools were found, though some of the hazel-nuts, which were very abundant, had been gnawed (by squirrels?). Many stumps were still in a vertical position. The movement of submergence must have been uniform, as it had not disturbed the approximate horizontality of the old forest ground, and must have amounted at the least to 18 feet, the greatest tidal range on that part of the coast, but there are no data from which to calculate how much greater it may have been.

3. ASTRONOMY.

(Including the Proceedings of the Astronomical Society.)

The careful examination of the photographs of the recent total solar eclipse in America has revealed a very interesting fact respecting the sun's corona. It has long been questioned whether this appearance belongs to the sun or is merely an optical effect due to our own atmosphere. It appears from the careful comparison of the photographs taken during the progress of the last eclipse, that the moon *passed over* the corona. The reader will remember that it was from observations of this sort, made nine years ago, that astronomers were led to the conclusion, now incontrovertibly established, that the prominences belong to the sun. There seems little reason for doubting that we may now come to the same conclusion respecting the corona.

It must be mentioned, however, that many eminent physicists and astronomers are still disposed to question the justice of this conclusion. Passing over the observations made by Mr. Pickering during the total eclipse, from which he is inclined to think that the corona belongs to the moon, we may dwell on sounder reasons which have been alleged against the belief that the corona belongs to the sun. Recent observations of the spectra of the prominences by Mr. Lockyer and other astronomers, compared with the careful study by Dr. Frankland of the corresponding spectra of terrestrial elements under varying circumstances of pressure and temperature, have led to the belief that the part of the sun's atmosphere which lies above his photosphere is not very dense,—certainly not by any means so dense as it would be if the corona were in reality a solar atmosphere.

On the other hand, Professor Young, an American astronomer, has made a highly significant observation. He has found that the spectrum of the corona exhibits the same bright lines as the auroral spectrum. Professor Harkness also found that the corona gives a bright-line spectrum, but superposed on a continuous one. Now when we combine Professor Young's observation with Ängstrom's discovery that the Zodiacal Light gives the same spectrum as the Aurora, it becomes one of the most interesting, and at the same time one of the most perplexing, ever made by astronomers. A bright-line spectrum indicates gaseity, and we cannot believe the corona to be a gaseous solar envelope, nor indeed to be gaseous at all, if we accept Lockyer's observations. Nor can one understand the Zodiacal Light to be gaseous.

Perhaps, however, all these observations may be reconciled by regarding the spectrum of the corona to be not necessarily indicative of the gaseity of this object in its entirety. Electrical discharges taking place between the particles (probably solid) of which the Corona and the Zodiacal Light consist would give a spectrum of bright lines. Then also we could understand the continuous spectrum seen by Professor Harkness, since the bodies forming the corona would reflect the solar light.

The whole subject is, however, at present full of difficulty and perplexity. In future eclipses the corona will doubtless attract a large share of the observer's attention.

Another result of the American eclipse observations has been the suggestion by Professor Young of a new mode of observing the coming transit of Venus. It was found that the approach of the moon to the sun's limb was cognizable before the moment of actual contact, owing to the gradual obliteration of the bright lines belonging to the spectrum of the chromosphere; and Professor Young suggests that the approach of Venus might be observable in the same way in 1874 and 1882. There are, however, many difficulties in the application of this method. In particular the method applies to external contacts, and the preparations hitherto made have had reference to internal contacts. At some of the best places for observing internal contacts, external contacts will not be observable at all. Then astronomers are not quite certain at what part of the sun's limb contact will take place, nor at what angle Venus will cross the limb. These circumstances would leave the spectroscopist small chance of success in an observation of so delicate a nature.

It remains to be seen, however, whether spectroscopic observation may not be applicable in other ways. For example, Mr. Huggins has suggested that instead of the slit being placed at right angles to the sun's limb, it should be placed tangentially. Mr. Proctor has recommended an open slit, placed tangentially so as to include the solar cusps before internal contact. These cusps would give two continuous spectra, the approach of which towards each other would indicate the moment of internal contact more exactly than the approach of the cusps.

The discovery of a small comet by the indefatigable Tempel has to be recorded. No observations of special interest have been made upon this object, however.

The November meteors have not been very conspicuous in Europe, this year. Unless we hear of star-showers in America, we must conclude that the denser part of the meteor-stream has now passed completely away from the neighbourhood of the earth's orbit. In that case we need not look for any remarkable display of the November meteors for some twenty-eight years or so.

Zöllner, the eminent photometrician and astronomer, has devised a new form of spectroscope for observing the stellar motions of recess and approach. The plan may be briefly described as follows:—The line of light which is to be analyzed by the spectrum is in the focus of a lens for parallel rays. These parallel rays are divided into two portions, each passing through two systems of direct-vision prisms, placed one below the other, and with their refracting edges turned in opposite directions. It is clear that by this arrangement two spectra are formed, the red end of one opposite the blue end of the other, and *vice versâ*. These spectra are observed together by means of a small telescope, the object-glass of which is divided into two adjustable parts by a line parallel to the length of the two spectra. It is thus possible to bring any line of one spectrum into coincidence with any line of the other, or even partially to superpose two lines. Now it is clear that if a celestial object is moving from or towards us at such a rate as to produce an appreciable effect on the position of a given bright line, Zöllner's arrangement will exactly double the effect. This, however, is not the chief advantage of the arrangement. In fact this is, in reality, no advantage at all (though Zöllner appears to think differently), for it is obtained by an arrangement which halves the light of the spectrum; and by simply doubling the dispersive power the same increase of effect could be obtained at exactly the same cost. The great advantage promised by the new arrangement is this, that there will be no occasion to compare a line directly with the corresponding line of a terrestrial element. Thus, supposing we wish to determine whether a star is moving from or towards the earth, by observing a particular dark line in its spectrum, we should in the first place adjust the two spectra so that this line seen in one would be brought into coincidence with the same line seen in the other, supposing there were no motion of recess or approach. This can be done with great nicety by observing the corresponding bright line of a terrestrial element. Then the telescope being directed towards the star whose motion is to be determined, there will be found no longer to be coincidence, if the star is in motion either from or towards the eye. By observing how much the micrometer screw by which the divided object-glass is adjusted has to be moved in order to secure coincidence, it becomes possible to estimate the rate of the star's motion. Zöllner believes that the probable error of a single observation will correspond to a motion of less than half-a-mile per second.

There will be an eclipse of the moon, partly visible at Greenwich, on January 17th. The eclipse will begin at noon of that day, and the moon will rise (at Greenwich) slightly eclipsed, and obscured by the penumbra. The last contact with the penumbra will take place at 5 h. 37 m. P.M.

There will be a partial eclipse of the sun, invisible at Greenwich, on January 31st.

Jupiter will remain for some time a conspicuous object in the western skies after sunset On March 18th Saturn will be in quadrature preceding opposition. Venus will be at her greatest brilliancy as an evening star on January 18th.

PROCEEDINGS OF THE ASTRONOMICAL SOCIETY.

As usual at this season we have but one number of the Monthly Notices—the supplementary number—to report on. It contains but six papers, and four of these are by one author.

Dr. O. Pihl gives a short paper on the subject of the cluster in Perseus, known as 34 Messier, which he has been studying since the year 1860. He indicates certain errors in his former estimates of the declinations of stars in this cluster, these errors resulting from an error in one of the co-efficients employed for reducing the declinations of the stars.

Mr. Proctor supplies a calculation of the comparative clinging of Venus to the solar limb during the transits of 1874 and 1882. From this it appears that the interval between real and apparent internal contacts will vary from 29·41 sec. to 35·11 sec. in 1874, and from 20·46 sec. to 21·39 sec. in 1882. Hence the observed difference of duration, or of absolute time, in 1874 should exceed the corresponding differences in 1882 in the proportion of 1·547 to 1, to have an equivalent value.

He adds a note on the later transit, giving the places where ingress and egress are most accelerated by parallax, as he had already done for the transit of 1874. He remarks that the corrections necessary for the transit of 1882 are much less than those for the transit of 1874, not one of the places now determined differing by much more than 300 miles from the place obtained when phase and parallax are neglected.

The Astronomer Royal supplies a most valuable contribution to science in the form of "A Note on Atmospheric Chromatic Dispersion as affecting Telescopic Observation, and on the Mode of correcting it." Every astronomical observer is familiar with the annoying indistinctness of objects observed near the horizon. In such observations as will have to be made during the coming transits of Venus, it would be of the utmost importance to get rid of this indistinctness. There would then no longer be any necessity for limiting the stations where observers should be sent to places where the sun would have a considerable elevation above the horizon. And this would be an immense advantage, because at all the stations which would otherwise be the best the sun will be low. Now the Astronomer Royal has shown that by means of a set of flint prisms, of small refracting angle, the observer can get rid in great part of the annoying dispersion we have spoken of. One prism only is used at a time, the prisms of the larger refracting angles being used for an object close to the horizon. The following reports by Mr. Carpenter (of the Greenwich Observatory) establish in the most satisfactory manner the value of the new method.

1869, July 15, 11 h. 50 m. to 12 h. 20 m. Saturn, zenith-distance about 82°, viewed with the great equatorial power 245. Atmospheric disturbances very bad:—Prism 12° corrected the dispersion perfectly; prism 8° corrected it fairly; prism 6° corrected it partially; prisms of smaller angle had no effect.

1869, July 21, 9 h. The moon, zenith-distance about 78°, viewed with the altazimuth, power about 100. Prism 2° slightly diminished the colour; prism 4° better than the last; prism 6° destroyed the colour entirely. The definition of the details about the moon's ragged edge very much improved. Prisms of larger angle gave an opposite dispersion.

This plan is obviously as satisfactory as it is simple. It cannot but be regarded as of extreme value and importance; and, simple as it is, will take high rank among the many important improvements which the Astronomer Royal has effected in the science of Observational Astronomy.

Mr. Proctor puts forward, in a paper "On the Distribution of the Nebulæ," illustrated by four folio engravings, a new theory respecting the constitution of the universe. He expresses his belief that the nebulæ are not external galaxies, but that all their varieties are included within the sidereal system. In another paper he indicates a method for measuring the discs of those stars which are liable to be occulted by the moon. This method consists in causing the image of a star to rotate rapidly in a circle, which is itself rotated, but less swiftly. Thus the image of a star follows an epicycloidal path, many coils of which will be visible simultaneously, owing to the persistence of luminous impressions. When the moon occults a star (a process which in reality occupies but a small fraction of a second) the coils will vanish, but according to the greater or less duration of the occultation a larger or smaller arc of the coil last formed will exhibit a gradual fading-off of light towards its extremity. Mr. Proctor has calculated that a star ten times as far off as *a* Centauri, and having a real diameter as large as our sun's, would give an arc of fading light about 56 degrees in length.

4. BOTANY.

Edible Fungi.—During the last few years great attention has been paid by botanists on the one hand, and epicures on the other, to the edible qualities of certain fungi. Notwithstanding the prejudice generally entertained against this class of vegetable productions, extending in Scotland, Wales, and some parts of England even to the common mushroom, there is no question that a considerable number of species, very abundant in this country, are not only wholesome, but delicious articles of diet, and are at least as easily distinguished, with a little practice, from the poisonous or suspicious species, as berries or other wild fruits. Containing a larger proportion of nitrogen than any other family of the vegetable kingdom, they furnish an abundant supply of nourishment at a period of the year when very little else is to be obtained. It is calculated that there is scarcely a parish in England where tons of wholesome food are not allowed to waste every year, to say nothing of the facilities for their artificial culture. Mr. Berkeley reckons that there are at least 30 distinct English edible fungi; Dr. Curtis has partaken of 40 in North Carolina, and enumerates 111 species in that state alone reputed to be edible. Fries, the greatest living cryptogamist, is publishing a large work on the edible and poisonous fungi of Sweden; several works of a similar character have recently been brought out in Italy; in our own country the Rev. M. J. Berkeley, Mr. Worthington G. Smith, and Dr. Bull of Hereford, may be mentioned as having paid special attention to the subject. In addition to the mushroom *Agaricus campestris* and the truffle *Tuber æstivum*, the following species are wholesome, pleasant to the taste when cooked, easily distinguished from all other species, and more or less abundant in different parts of the country:—*Agaricus arvensis*, or the horse-mushroom; *A. procerus*, the parasol-mushroom; *A. ostreatus*, the vegetable oyster, growing on the trunks of trees; *A. melleus*, abundant on dead stumps; *A. orcella*, the vegetable sweet-bread; *A. prunulus*, the plum-mushroom; *Morchella esculenta*, the morel; *Hydnum repandum*, the hedge-hog; *Fistulina hepatica*, the vegetable beef-steak, on the stumps of hollow trees; *Coprinus comatus*, very common in gardens; *Marasmius oreades*, the fairy-ring champignon; *Boletus edulis*, in woods; and *Lycoperdon giganteum*, the giant puff-ball, when in the young state.

Many of these species are favourite articles of food in the autumn and winter with the peasantry in various parts of the Continent, and are everywhere sold in the markets. Our common mushroom is among the kinds forbidden by the police regulations to be sold in Rome, but is to be met with in the markets of Palermo and Messina.

Acclimatization of Half-hardy Plants.—Great efforts have recently been made in France to naturalize trees and shrubs—natives of warmer climates; and these have been attended with considerable success in some instances. The Bamboo, introduced at Tours, Macon, and Angers, has succeeded admirably, and has withstood a very considerable degree of frost. It seems likely to flourish even in the climate of Paris, where it is grown in the gardens of the *Société d'Acclimatation.* Several species of *Eucalyptus*, especially the *E. globulus*, have also been planted extensively in the Department of the Var, where they have been found to resist the destructive north-west wind known as the *mistral.*

The Fertilization of Winter-flowering Plants.—Mr. A. W. Bennett contributes to the first number of the new scientific magazine, 'Nature,' the results of some observations on the fertilization of those plants which habitually flower in the winter, when there are few or no insects to assist in the distribution of the pollen. He finds that in those wild plants which flower and produce seed-bearing capsules throughout the year, as the white and red dead-nettles, shepherd's purse, chickweed, groundsel, &c., the pollen is uniformly discharged in the bud before the flower opens. Many garden-plants, on the other hand, natives of warmer countries, but which still flower with us in the depth of winter, never bear fruit in this climate, and in them the pollen is not discharged till the flower is fully open. Of this class are the yellow jasmine and the *Cheimonanthus fragrans*, or all-spice tree; in the latter species the arrangement of the pistil and the stamens is such as to render self-fertilization impossible.

Leonardo da Vinci as a Botanist.—In the recently commenced 'Nuovo Giornale botanico Italiano,' published at Florence, Signor Uzielli has an interesting article on some botanical observations of Leonardo da Vinci, showing that to the great painter is due the credit of the first observation of certain points in the structure of plants, which has been generally attributed to writers of a considerably later date. The constancy of a uniform arrangement of the leaves on the branches in the same species, known as the Law of Phyllotaxis, is stated in botanical works to have been first observed by Grew and Malpighi towards the close of the seventeenth century. Da Vinci, however, who lived from 1452 to 1519, records observations to the same effect, though not so accurate, in his great 'Treatise on Painting.' To the same two botanists is also ascribed the discovery of the mode in which the stems of exogenous trees increase beneath the bark by the formation of concentric rings of wood, from the number of which the age of the tree can be determined. This had, however, also been already observed by Da Vinci, and is recorded in passages in the same work.

Arctic Flora.—Dr. Berthold Seemann discusses in the 'Journal of Botany' the question whether vegetation extends to the North Pole, supposing land exists there. He answers the question in the affirmative, maintaining that excessive cold in winter exercises but a limited influence upon a vegetation which, like the Arctic, enjoys the protection of a thick covering of snow, and is besides in a state of inactivity. The temperature of the summer during the months of July and August has by far the greatest share in the distribution of vegetable life in the northern regions; and the lowest temperature during those months is not found in the most northerly point yet reached by any exploring expedition, but in Winter Island on the eastern shores of the Melville Peninsula, where the mean temperature during July and August ranges between 34° and 36° F. That spot, which may be called the phytological pole, is nevertheless covered with vegetation; and, knowing as we do, that plants do grow not only on a frozen soil, but even, as in Kotzebue Sound, on the tops of icebergs, there is no reason to suppose that the terrestrial pole is destitute of vegetation. The most northerly berry-bearing plant yet recorded is *Vaccinium Vitis-Idæa*, or the cranberry, gathered in Bushman Island, on the north-west shore of Greenland, by Captain W. Penny, or in latitude 76° N., longitude 66° W. The most northerly berry-bearing genera are *Vaccinium*, *Oxycoccus*, *Rubus*, *Cornus*, and *Empetrum*. It is stated that occasionally berries ripen in Lapland.

Vegetation of Howe's Island.—The flora of this island, 300 miles from Sydney and 500 from Norfolk Island, has been investigated by Mr. Charles Moore, and is found to resemble much more closely that of the latter island than of Australia. Its situation is 31° 36′ S. lat., 159° 5′ E. long.; it is 4½ miles in length and 1¼ in breadth, possesses two mountains about 2500 feet high, and is entirely covered with vegetation, with no barren spots except the coast and the precipitous cliffs. The indigenous species are very few, most of them being peculiar to the island and undescribed. Of Endogens there are four species of Palm, all undescribed and of great value to the natives; two species of *Pandanus*; three Grasses; two Orchids; a *Juncus*; a *Smilax*; one species belonging to *Iridaceæ*, one to *Amaryllidaceæ*, three to *Cyperaceæ*, and one to *Commelynaceæ*. All the clearings are, however, covered with introduced European plants, including the couch-grass. Among Exogens, the Australian *Proteaceæ* and *Leguminosæ* are entirely wanting; *Epacridæ* and *Myrtaceæ*, so abundant in Australia, are represented, the former by a single species, a tree 30 or 40 feet in height, growing at great elevations; the latter by two, the leaves of one of which are used by the natives in the place of tea; a very remarkable undescribed *Ficus* forms a considerable portion of the larger vegetation, growing sometimes 100 yards across, with very numerous root-stems. The castor-oil plant and *Solanum laciniatum* are among the most troublesome introduced weeds. Ferns are very abundant, but of non-Australian types; the genera *Adiantum* and *Aspidium*, so abundant in Australia, New Zealand, and Norfolk Island, were not observed.

The Lichens of Greenland.—Dr. Lauder Lindsay has worked out with great care, in an article read before the Botanical Society of Edinburgh, an account of all that is at present known respecting the Lichens of Greenland. While in 1840 only 59 species had been recorded, Dr. Lindsay is now able to enumerate 268 as natives of Greenland, and thinks that this number may probably be raised to 300. The degrees of latitude within which they have been collected range from 60° to 75°, the majority having come from about 70°, a few from as far north as 82°. The almost entire absence of arboreal vegetation in Greenland necessarily affects the character of the Lichen-flora, very few corticole and foliaceous species being found, but a great preponderance of the saxicole forms. One prominent feature is the great abundance of the sombre-coloured *Umbilicariæ*, giving in many parts a funereal colouring to the landscape. Deducting the species that are mainly or entirely confined in their distribution either to Greenland or to Arctic countries, the majority at least of the remainder occur on the Scandinavian Alps, and many of them on the Alps of Scotland and Switzerland, or generally on those of continental Europe; while a considerable number are common British forms. The lichen-flora of Greenland differs, on the other hand, very considerably from that of Arctic America. The lichens of Spitzbergen and its islets are as numerous as those of Greenland, notwithstanding the smaller area; while the whole list of Melville Island lichens contains only twelve species. There is no record of any species of lichen being turned by the Greenlanders to any economic purpose, notwithstanding the abundance of *Cladonia rangiferina*, or the "Reindeer-moss," and of other species which, in other Arctic countries, have been serviceable in supplying the wants of man or animals.

Hibernation of Duck-weed.—It has long been known that some species of *Lemna*, or duck-weed, produce, at the approach of winter, leaves of a different character to those formed in the spring, which fall to the bottom of the pond or stream, enabling the plant to live through the winter. A series of more accurate observations on this point is recorded by M. Van Horen in the 'Bulletin de la Société Royale de Botanique de Belgique.' The species of *Lemna* indigenous to Belgium are the same as those found in this country; of these

M. Van Horen finds that two only, the *L. polyrrhiza* and *gibba*, produce leaves of a different form in winter; while with the three other species, *L. minor, trisulca,* and *arrhiza*, the ordinary leaves live through the winter, remaining on the surface. In *L. polyrrhiza* these winter-leaves first make their appearance in August or September. They are much smaller than the ordinary leaves, reniform or sometimes elliptical, olive-brown on both sides, and not gibbous beneath; their roots are exceedingly minute, and at first hidden within the leaf. The aëriferous cells which serve to support the ordinary leaves on the surface do not exist, causing the winter-leaves to resemble an undeveloped bud. In consequence of the absence of these vessels they are heavier than the water, and fall to the bottom as soon as any agitation of the water detaches them from the parent-leaf, which perishes with the first frost. At the ordinary period of the revival of vegetation, a small bubble of oxygen appears on the upper surface of these submerged leaves, which carries them to the surface, from which they again descend should the temperature fall below a certain point. In *Lemna gibba*, leaves of a similar character, were observed hibernating beneath the water, differing in shape, size, and structure from those developed during the summer.

Evaporation of Water and Decomposition of Carbonic Acid by Plants.—An interesting and important series of experiments has been made by M. P. P. Dehérain, of Paris, for the purpose of determining the natural agents most efficacious in promoting the physiological functions of the leaves of plants, the evaporation of water, and the decomposition of carbonic acid. The results arrived at are as follows:—1. These two processes are carried on simultaneously and with corresponding intensity, the same agents which facilitate the one being operative also with the other. They proceed more rapidly from the upper smooth and hard surface of the leaves than from the under-surface. 2. The principal agent in determining these changes is not temperature, but light. While the amount of water given off was hardly affected by any changes of temperature, proceeding almost with equal rapidity even when surrounded by ice; in bright sunshine leaves were found to give off, in long exposure, more than their own weight of water, while in diffused light it amounted to only six to eighteen per cent., and in total darkness was scarcely perceptible. The evaporation and condensation of water proceeded with equal rapidity when the air was perfectly saturated with moisture. 3. The different rays of light are not equally efficacious in promoting these actions. M. Dehérain found, as the result of a number of experiments, that, with an equal intensity of light, the red and yellow rays, which have little photographic power, cause in the same time the decomposition of about five times as much carbonic acid, and the evaporation of a corresponding amount of water, as compared with the action of the blue or violet rays, which are the most active in decomposing chloride of silver.

Viridescence of Leaves.—M. Prillieux has, on the other hand, shown, by a series of experiments on barley, that the production of the green colouring matter of leaves proceeds more rapidly in diffused light than in the direct light of the sun, in opposition to the production of oxygen, which is the more abundant the stronger the light.

Peloria in Labiatæ.—M. J. Peyritsch has presented to the Academy of Sciences at Vienna some remarkable instances of "Peloria," that is, of abnormal regularity in flowers usually irregular, observed in the order *Labiatæ*. They occur in *Stachys sylvatica*, the common woundwort; *Betonica officinalis*, the common betony; and in seventy individuals of *Galeobdolon luteum*, the yellow dead-nettle. In the latter instance the flowers are formed by the increase of two segments of the calyx, and by an alteration in the form of the divisions of the upper lip of the corolla, so that they become similar to the lateral lobes of the lower lip. The stamens are perfectly normal, and bear well-developed pollen; but the carpels are abortive.

The Leaves of Conifers.—At the meeting of the American Association for the Advancement of Science, held at Chicago, Mr. Thos. Meehan read a paper on the leaves of *Coniferæ*. He pointed out that the true leaves of *Pinus* consist of bud-scales; and what are popularly known as the leaves are in reality arrested phylloid shoots. The chief portion of the true leaves in most plants belonging to this order is adnate to the stem; sometimes they have the power of developing only into scale-points; sometimes into foliose tips. In *Larix* the true leaves are linear, spathulate, entirely adnate to the stem. There are two kinds of stem-growth. In one case the axis elongates and forms shoots; in the other, axile development is arrested and spurs are formed. On the elongated shoots the leaves are scattered; on the spurs they are arranged in whorls. There are therefore in the larch two forms of leaves: the one free, the other adnate. In *Cryptomeria* the true leaves adhere for four-fifths of their length on vigorous shoots; in *Juniperus*, for nearly their whole length on vigorous shoots; while on weaker branches they are almost entirely free. In *Pinus* the phylloid shoots are situated in the axils of the true leaves. Mr. Meehan sums up his observations as follows:—The true leaves of *Coniferæ* are usually adnate to the branches. Adnation is in proportion to the vigour of the genus or species; or of the individuals in the same species; or of the branches in the same individual. Many so-called distinct species of *Coniferæ* are probably only varieties of the same species in various states of adnation.

Scorching of Leaves by the Wind.—M. Marchand, engineer of Fécamp, in Normandy, has made some observations on the effect produced on the leaves of various trees by the violent storm of the 12th to the 16th of November. The wind was from the north-west; and on that side the leaves of nearly all the trees growing near the coast, except the bay, ivy, and tree-mallow, were scorched as if by fire, and lost about 39 per cent. of their normal weight; and were found to have absorbed an appreciable amount of sea-salt, which no doubt obstructed the circulation of the sap and caused them to shrivel up. The leaves exposed to the south-east were not similarly affected.

Japanese Sea-weeds.—At a recent meeting of the Royal Academy of Amsterdam, a collection was exhibited to illustrate the care taken by the Japanese in applying to beneficial purposes the natural products of their country. The collection consisted of sixteen species of *Algæ* which are useful for food or other purposes, together with fabrics manufactured from some of them. Several of the species were altogether new; in other instances the application was entirely novel.

5. CHEMISTRY.

MR. J. ALFRED WANKLYN has made known a very unexpected fact. He says that when chlorine gas is passed over metallic sodium—even when the metal is fused, and whilst in a state of fusion, shaken in contact with the gas so as to expose fresh metallic surface—there is no increase in weight, and of course no action.

The increasing demand for albumen, especially for the use of calico-printing, has at various times led to attempts to obtain a supply of this article from the blood of slaughtered oxen and sheep. M. Dolfus-Galline describes a process invented by him, and actually in operation on a large scale at the *abattoirs* of Dornach, France. The process is based upon the fact of the coagulation of the cruorine of the blood, and its separation from the serum, the latter yielding, by cautious management, a dried albumen, which can be applied instead of egg albumen for clear and bright colours. Ten litres of serum yield 1 kilo. of dry colourless albumen; the blood of two and a half oxen, ten sheep, or seventeen calves, produces the same quantity of dry albumen, *viz.* 1 kilo.

Referring to Professor Graham's researches on the occlusion of hydrogen by palladium, M. Favre states, that according to his experiments the hydrogen in palladium saturated therewith is present as a chemical compound, and not simply in the state of condensed gas. He also states that the vapour of boiling mercury is as little a conductor of electricity as hydrogen is, and that therefore the non-conductibility of hydrogen for electricity cannot be regarded as an objection to its being a metal.

M. Chevrier has studied the action of vapour of sulphur on various gases. With oxygen it forms a slightly explosive mixture under some conditions; but usually the vapour of sulphur burns off quietly. With hydrogen it yields sulphuretted hydrogen gas very abundantly. With nitrogen the author found no action. With proto- and bin-oxide of nitrogen it forms sulphurous acid; nitrogen is set free, and if a frigorific mixture be applied to the apparatus containing the mixed gases and vapours, large so-called lead-chamber crystals are obtained. Oxide of carbon yields, with vapour of sulphur, oxysulphide of carbon.

When sodium is thrown upon water, the hydrogen does not kindle, as is well known, unless the water be warmed, or the metal confined to one spot by blotting-paper. Mr. T. Bloxam, lecturer on Chemical and Natural Philosophy, Cheltenham College, has, however, found that if sodium be dropped upon nitric acid of specific gravity 1·36 (ordinary commercial), the hydrogen burns with ease; but if the acid be diluted, this result ceases. The hydrogen ceases to kindle when the acid is diluted to specific gravity 1·056. The residue contains a fair amount of ammonia.

Dr. Emmerling has been carrying on experiments on the action of water on glass and porcelain. The leading features of his results are the following:—The action of boiling liquids upon glass vessels is proportionate to the duration of time of boiling; it is proportionate to the surface which is in contact with the boiling fluid; it is independent of the quantity of fluid which evaporates during a given time; it decreases with the decrease of temperature of the solution; alkalies, even in dilute solutions, attack glass very strongly; acids, excepting sulphuric acid, generally act less than pure water. Among the salts, those act most energetically whose acids produce insoluble salts with lime, *e.g.* sulphate and phosphate of soda, carbonate of soda, and oxalate of ammonia, the action of each of which increases with the degree of concentration of the solution; those salts which form in water, readily soluble lime-salts, act less strongly than pure water alone, and with the greater degree of concentration of these salts the action decreases; Bohemian glass stands acids better than glass containing soda; Berlin porcelain is only perceptibly acted upon by alkalies.

Dr. H. Schwartz has observed that when the pulverulent metallic zinc which is deposited in the tubes of the Belgian zinc smelting-furnaces is mixed with amorphous phosphorus in powder, and this mixture is gently heated in a hard glass combustion-tube, while at the same time a current of dry hydrogen gas is passed through, phosphide of zinc is formed. From the phosphide of zinc so obtained, phosphuretted hydrogen may be readily prepared by means of dilute sulphuric acid, or by boiling with caustic potash.

A method of strengthening and rendering woven tissues impermeable to water has been invented by M. Newman. A sulphuric acid bath is made containing acid of about 1·6 specific gravity, and kept at a temperature of 57°. The woven tissues, cotton or linen, are rapidly passed through this bath, being only left in contact with the acid for from ten seconds to two minutes, according to the nature of the tissue, which is immediately after passed through very cold water, and next submitted to a thorough washing process. The effect of the action of the acid is the formation of a varnish-like matter, which, especially after it has been regularly spread over the fabric and incorporated therewith by hot-pressing and calendering, greatly increases the strength of the fabric, and renders it simultaneously impervious to water.

The manufacture of oxygen gas on a commercial scale is increasing in Paris; Mr. Fowler, who has described one of the factories, says that 500 pounds of manganate of soda, furnish 2½ cubic yards of oxygen every hour. This charge is placed in a retort and superheated, steam passed over it; in five minutes all the oxygen is extracted from this quantity of the salt. Hot air passed over this residue for five more minutes restores all the oxygen given up, and the result of an hour's continuous work, or six extractions of oxygen and six re-oxidations, is 2½ cubic yards of oxygen. This oxygen, when it issues from the gasometers, contains about 15 per cent. of nitrogen, but by letting the first portions escape, the quantity of this mixture can be reduced to 2½ per cent. M. Tessie du Mothay affirms that one ton of manganate of soda will yield 100 cubic yards of oxygen daily, or more than 36,000 per year; and this without having to renew the salt once.

According to M. Kessler, when burning magnesium wire is placed in a vessel containing carbonic acid, the latter is decomposed, and carbon deposited. Some nitric acid should be poured into the vessel at the end of the reaction in order to dissolve the magnesia resulting from the combustion, and to make the deposit of carbon distinct. Water having been poured in a rather wide-mouthed flask, it is made to boil as briskly as possible; when, after this boiling has been continued for some time, previously-ignited magnesium wire is held deep down in the mouth of the flask, it continues to burn. The same metal burns with great brilliancy in nitrous and nitric oxide, also in sulphuretted hydrogen and sulphurous acid, but is extinguished by carbonic oxide.

Dr. Poselger deserves the thanks of the public for his determining, by positive experiments, that the death of fine trees growing along the streets and promenades of many, especially continental, towns, is not due, as has been too often asserted, to the effects of leakage in gas-mains. From the author's experiments made with trees and shrubs, it is a settled point that no damage can accrue to the trees, nor their growth be interfered with, by any quantity of gas which may escape in the soil and find its way to their roots.

MM. Martius and Mendelssohn-Bartholdy have tried whether it would not be possible to prepare chloral, the new anæsthetic, in large quantities, so that if this substance should become used in pharmacy, it could be easily obtained in a pure state. The hydrate of chloral answers this purpose by far the best: it is a white crystalline mass, endowed with considerable hardness; it dissolves readily in water, and is devoid of any smell of chloride of carbon or hydrochloric acid, while it exhibits its own peculiarly strong smell. The authors have exhibited several pounds weight of chloral, and hope shortly to be able to exhibit the synthesis of chloroform by an easily executed method, and also of trichloracetic acid.

Dr. Calvert states that when hypochlorite of lime and sulphate of ammonia are mixed, nitrogen gas is immediately given off, even without the application of heat. The author observes further, that all nitrogenized animal matters (such as albumen, fibrin, gelatine, silk, feathers, and skin) yield, when mixed with a solution of hypochlorite of lime, especially when heat is applied, a large quantity of nitrogen and carbonic acid.

Dr. C. Winkler, during some experiments on the bleaching of wood-pulp for paper manufacture, has found that neither chlorine, bromine, nor any substances the activity of which is due to oxidation, will answer the purpose, the result always being the production of a decidedly yellow and sometimes even brown tinge. Sulphurous acid does not completely answer the purpose; the destruction of the natural colouring matters by means of fermentation did not lead to any good result.

When the lecture-room of a chemical laboratory is provided with a sufficient supply of water under strong pressure, it is possible to exhibit there an experiment which, owing to a deficient pressure of water in such rooms, has been almost unnoticed. The experiment is the following:—Under an ordinary water-tap, the opening of which has from 10 to 12 metres diameter, a large-sized porcelain basin is placed, containing from 15 to 20 kilos. of mercury; the water-tap being suddenly opened, a strong flow of water is caused to fall into the basin at a height of from 8 to 10 centimetres from its bottom. On turning off the flow of water again, it will be seen that on the surface of that fluid there float about bubbles of mercury, usually exhibiting a diameter of only 1 centimetre, but occasionally some are found of two or three times that size. As a rule these bubbles are very ephemeral; now and then, however, it happens that some may be caught along with a quantity of water in a small beaker glass, and on the mercurial bubbles bursting, it will be seen how very small a quantity of mercury these bubbles consist of. Professor Hofmann mentions that he saw this experiment first exhibited in the lecture-room of the Royal College of Chemistry, London, when, twenty years ago, Professor Melsens, from Brussels, was on a visit there.

Caustic baryta is likely to become of considerable use for industrial purposes. M. Nicklès has described its mode of preparation. It appears that four operations are required:—(1) Conversion of native sulphate of baryta into sulphide of barium; this is effected in a continuous manner, in a peculiarly constructed furnace, the sulphate being previously mixed with a reducing substance; (2) the conversion of the sulphide of barium into hydrate of baryta, by means of hydrated oxide of zinc; (3) dehydration of the hydrate of baryta by ignition along with sawdust; (4) regeneration of the substance which has served for the desulphuration of the sulphide and obtaining of sulphur.

M. E. Underhold states that the hardest steam-boiler incrustations are formed when the quantity of carbonate of lime amounts to from 20 to 25 per cent. of the entire mass. He has found, by an experience extending over several years, that some kinds of clay when suspended in the water contained in steam-boilers, prevent the particles of carbonate and sulphate of lime dissolved in the water, even if the latter is very hard, from clinging together and becoming fixed to the sides of the boilers, forming there a hard incrustation. A series of experiments, made on purpose and continued for a sufficient length of time to yield a reliable result, has fully proved that the addition to the feed-water of the steam-boilers of fatty clay, especially that known as fuller's-earth, entirely prevents boiler incrustations, even where, of necessity, very hard water has to be used as feed-water. A loose soft mud is deposited as soon as the motion of the water due to the boiling ceases on cooling. This mud readily runs off on opening the valve of the boiler.

Some valuable sulphur deposits have been discovered in the island of Saba, Netherlands, West Indies. The rock composing almost the entire formation of Saba is trachytic porphyry, which contains glassy felspar and hornblende in crystals, disseminated through a dark reddish-coloured vase. The sulphur deposit is located on the northern part of the island of Saba, and extends for a distance of more than a mile along the sea line. The stratum of sulphur varies in thickness from 15 to 50 feet; its elevation above sea-level varies from 45 to 200 feet. This island has a surface of about 9 English square miles, or 5760 acres, and contains 1794 inhabitants.

6. ENGINEERING—CIVIL AND MECHANICAL.

The Suez Canal.—The past quarter will long be memorable in the annals of Civil Engineering for the completion and successful inauguration of one of the most wonderful works of modern times. The Isthmus of Suez Canal, just completed, is, however, the realization of no modern conception. The idea of traversing that isthmus, or at least the greater portion of it, is so ancient that the original author of it cannot now be named; but evidences remain to show that, at some very remote period, a canal really did exist between the river Nile and the Red Sea. As far as can be ascertained it was undertaken by Necho, about six centuries before the Christian era, and subsequently completed by Darius. There exists amongst ancient writers some difference of opinion as to the precise character of the canal and its exact route, but there can be no doubt that a canal was once made, extending from the Nile to the Bitter Lakes, a distance of about thirty-four miles, which, being filled with fresh water by the rising of the Nile, was navigable for at least such portion of the year as the Nile was in flood: it is also certain that a smaller canal was continued from the Bitter Lakes to the Red Sea, near Suez. These works, which for many centuries had been allowed to fall into decay, were restored about A.D. 649 by the Caliph Omar; but instead of the restored canal joining the Nile, near Bubastis, it curved southward to Cairo, and was named the 'Canal of Cairo.' This canal appears to have continued open until about the year A.D. 767, affording means of water communication between the Nile and the Red Sea. Subsequently to the above date there do not appear any records of its existence; but at the latter part of the last century the Emperor Napoleon Bonaparte, during the time of the Egyptian expedition, caused a complete survey of the old canal and of its route to be made by M. Lepère. That officer's report was dated in 1799; but in consequence of the withdrawal of the French from Egypt no further action was taken in the matter.

The next report on the subject which deserves notice was that of Captain Chesney, of the Indian army, in 1830, who proved the perfect practicability of the project, and his views were subsequently verified by surveys undertaken under Robert Stephenson. For many years previously Linant Bey had considered the project of cutting a navigable canal across the Isthmus; and in 1845 an association was formed with the view of carrying the work into effect. Prior to that date, however, M. de Lesseps had formed his conclusions on this subject; and in 1854 he suggested his ideas to Said Pacha, by whom the project was warmly entertained. A commission, composed of the principal engineers of Europe, was convened to examine the scheme, who visited the site in November, 1855, and in January following they submitted their report, in which the undertaken was represented as easy of accomplishment and certain of success, and the estimated cost was then set down at 200,000,000 francs. A concession was shortly afterwards given to M. de Lesseps for the construction of the canal; and after further careful investigations the works were set in hand, the completion of which was celebrated by the opening of the entire canal on Wednesday, the 17th November last.

The course of the canal is from Port Said, on the Mediterranean, through Lakes Menzaleh and Ballah, after which it is cut through some high ground at El Guisr, which separates Lake Ballah from Lake Timsah. Between the latter lake and the Bitter Lakes lies also a length of high land, extending from the shore of Lake Timsah to Serapeum, after which the canal enters the district of low, swampy land, known as the Bitter Lakes. It then reaches high ground once more at Chalouf, and for the remainder of the distance to Suez passes through high land in deep cuttings. The length of the canal is about 100 miles. The total expenditure upon the canal has been 434,000,000 francs; but according to a statement recently published the net cost, after allowing for the present value of plant, &c., has been 216,000,000 francs.

Blackfriars Bridge.—In addition to the above great international work, there have been completed, within the period under review, two important engineering projects within the city of London, namely, the reconstruction of Blackfriars Bridge across the Thames, and the erection of a viaduct across the Holborn Valley.

Old Blackfriars Bridge was first thought of in 1754, at which date there existed no means of communication across the Thames between London and Westminster Bridges; and in 1756 an Act was obtained for the erection of a bridge across the Thames in the neighbourhood of Fleet Ditch. On 26th April, 1760, a contract was entered into with a Mr. Phillips for the construction of a bridge for 110,000*l.*, from the designs of Mr. Robert Mylne. On the 31st October, in the same year, the first stone was laid by Sir Thomas Chitty, Lord Mayor, and the bridge was opened to foot passengers on the 19th November, 1766. It was not, however, until the 19th November, 1769, that it was finally completed and opened for wheel traffic. On the 8th June, 1864, old Blackfriars Bridge was closed, and the traffic diverted over a temporary wooden structure erected by its side. The design for the new bridge was prepared by Mr. J. Cubitt, and the estimated cost was 269,000*l*. Space will not admit of a detailed description of this bridge, which was opened by the Queen in state on the 6th November last.

Holborn Viaduct.—On the same date the Holborn Viaduct was completed and declared open to public traffic. This important work, extending from the top of Holborn Hill on the west to the top of Skinner Street Hill on the east, crosses over the ancient valley of the Old Bourne, affording a straight line of communication where two steep hills previously impeded the traffic. The works have been carried out from the designs of Mr. Heywood, the city architect, at a total cost of about 2,000,000*l*.

PROCEEDINGS OF SOCIETIES.

Institution of Civil Engineers.—Considerable indignation has been recently aroused amongst the members of the engineering profession in England and India, in consequence of a Circular Order issued by the Government of India, from which it was distinctly to be inferred that the practice of accepting bribes from contractors and others was recognized by the profession in England. At the first ordinary meeting of the Institution, on the 9th November, the President reported that on receipt of a copy of the Order in question, a meeting of the Council took place, at which a series of resolutions were passed totally repudiating the calumny, copies of which were forwarded to the Secretary of State for India. At a deputation of the Council, which subsequently waited upon the Duke of Argyll, his Grace promised to forward the representations of the Institution to the Government of India, and to call for some explanation as to the circumstances which led to the publication of the Order; and in a subsequent letter to the President of the Institution, his Grace declared that "he regarded with implicit confidence the indignant repudiation of the Institution of any recognition of the practice referred to in the notification."

Society of Engineers.—The principal paper which has been read before this Society in the present Session, is one by Mr. P. F. Nursey, on "English and Continental Intercommunication." After referring to the present defective means of transit across the British Channel, the author briefly alluded to a few impracticable suggestions which have, from time to time, been proposed for the purpose, and then referred more in detail to those projects which have been put forward by experienced engineers. These may be divided into three classes, namely:—1. Those for tunnelling under the bed of the sea between England and France. 2. Schemes for carrying a railway through submerged tubes laid at the bottom of the sea; and 3. For the improvement of the passage-boats, or, in other terms, the construction of a huge Steam Ferry between the two countries. A fourth class of projects may be enumerated, namely, those having for their object the construction of a high-level bridge across the Channel, but such hardly come within the category of practical schemes. That which can be constructed at least cost and with most expedition is the Channel Ferry project, and this we are inclined to think will, for the present at least, be found the most practical solution of the difficulty.

New York Society of Practical Engineering.—At a meeting of this Society, on 13th October last, a most useful and practical paper was read by Mr. C. Williams, C.E, on "Railway Accidents and the Means of Prevention." In the absence of wooden tie sleepers, the author advocated the laying of rails upon sleepers bedded upon sand confined in trenches formed either transversely or longitudinally with the track. The importance of securely attaching the rails to the substructure was dwelt upon; and, lastly, improved fish-joints and methods for avoiding the breaking of railway carriage axles were discussed, and the methods for effecting such means of security were dwelt upon at some length.

LITERATURE.

'The Theory of Strains in Girders and similar Structures,'* by Bindon B. Stoney, B.A.—The first volume of this work appeared three years ago. The present volume treats of the subject of girders under compression and in tension, as well as elasticity, temperature, and the practical designing and estimating of girder-work; and in the former part of the volume numerous references are made to the experiments carried out by Mr. Kirkaldy and Mr. Hodgkinson. As a text-book for practical engineers this will be found a useful work, but it would be impossible to enter fully into its merits within the space to which we are limited.

'A Practical Treatise on Concrete, and How to make it; with Observations on the Uses of Cements, Limes, and Mortars,'† by Henry Reid, C.E.—At the present day when the use of concrete and cements is being so largely introduced into almost all engineering works, a more perfect knowledge of their properties is a subject much to be desired, and every fresh information coming from a reliable source is much required. During the earlier period of the introduction of concrete, which, in this country, is attributed by General Pasley to Sir Robert Smirke, it was regarded as being only fitted for foundations, or hidden work of a similar kind; but of late years that material has acquired a higher standard, and is now being extensively employed in the construction of buildings of various kinds with most satisfactory and economical results. The preparation of concrete is treated very fully by Mr. Reid, who devotes distinct chapters to lime concretes, concretes with compound matrices, Roman cement concretes, and concretes made with Portland cement. He also gives descriptions of machinery for mixing concretes and mortars, as well as remarks on building by frames. In conclusion, some general observations of considerable value are given on the advantages possessed by Portland cement as a building material, in the course of which he mentions the success which has resulted from the use of such concrete as a material for pavements. Altogether this is a very useful work, which may beneficially be consulted by all classes interested in the use of concrete.

---

* Longmans, Green, & Co., London.

† E. and F. N. Spon, London.

7. GEOLOGY AND PALÆONTOLOGY.

(*Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.*)

Memoirs of the Geological Survey.—Two of these Memoirs, forming an important contribution to British Geology, have reached us during the past quarter. One is a very elaborate 'Essay on the Triassic and Permian Rocks of the Midland Counties of England,' by Edward Hull, M.A., F.R.S., &c. (now Director of the Geological Survey of Ireland). No less than twenty sheets of the 'Geological Survey' (one-inch) maps are referred to in this Memoir, which include parts of the counties of Gloucester, Hereford, Worcester, Warwick, Leicester, Stafford, Salop, Denbigh, Flint, Cheshire, Derby, Notts, York, and Lancaster. The rocks are treated in ascending order, under the following headings, or general classification:—

TRIASSIC SERIES ..	A 1.	Rhætic, or Penarth Beds.	
	A 2.	New Red Marl (Keuper).	
	A 3.	Lower Keuper Sandstone (Letten Kohle ?).	
	(B.	Muschelkalk, wanting in England).	
	C 1.	Upper Mottled Sandstone	(Bunter Sandstein).
	C 2.	Pebble Beds	
	C 3.	Lower Mottled Sandstone	
PERMIAN SERIES ..	1.	Upper Permian (Zechstein).	
	2.	Lower Permian (Rothe-todte-liegende).	

The Lower Permian series may be arranged under two distinct types of strata, called respectively the "Salopian" and the "Lancashire," which differ lithologically, and were deposited in separate hydrographical basins, the disconnecting barrier having been produced by the upheaval of the Lower Carboniferous rocks along a tract of country crossing from east to west below the central plain of Cheshire. Our readers will remember Mr. Hull's paper, recently read before the Geological Society, in which he entered fully upon this question.

The unconformity is noticed between the Triassic and Permian series, which was pointed out by Professor Sedgwick more than forty years ago; the newer beds rest indiscriminately on any of the older formations, whether Silurian, Devonian, Carboniferous, or Permian.

The lithological peculiarities of the beds exhibited in different localities and their organic remains are noticed. Though it is as well to mention that the subdivision of the Bunter Sandstone, or Lower Trias, into three members, which was propounded by Mr. Hull in the course of his detailed examination of the rocks over a large area, was altogether dependent on inorganic evidence.

Some little space is of course devoted to the beds of Rock-salt interstratified with the Red Marls and clays of the Keuper. The Rhætic, or Penarth Beds, are also briefly noticed; but these beds have not yet been traced farther northward than the outlier of Copt Heath, near Birmingham, and at Abbots Bromley, in Staffordshire. Mr. Hull is inclined to regard these beds as referable to the Triassic formation, although it seems to us better to regard them as passage-beds between the Lias and Trias—the lower beds passing into the latter, the upper being more closely related, and sometimes appearing to graduate into the Lower Lias above.

The Physical Geology of the Permian and Triassic periods are treated of; also the distribution of the Coal Measures beneath them.

The Bunter Sandstone is considered as a source of water-supply, and is regarded, with the exception perhaps of the Chalk and Lower Greensand, as by far the most important water-bearing formation in England.

In an appendix is given a list of the Fossils in the Warwick Museum, from the Keuper and Permian Sandstones, by the Rev. P. B. Brodie, revised by Mr. Etheridge, Palæontologist to the Survey.

The second Memoir is on the 'Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire, and the adjoining parts of Yorkshire,' by A. H. Green, M.A., F.G.S., Dr. C. Le Neve Foster, B.A., F.G.S., and J. R. Dakyns, M.A. They give a detailed description of the geological structure of the district, together with observations on the physical features and drainage, followed by an appendix, giving a list of the Carboniferous Limestone fossils of Derbyshire, furnished by Mr. Etheridge.

The formations described in this Memoir are as follow:—

Recent	Alluvium and River Gravels.
Post Pliocene	Boulder Beds.
Carboniferous	Lower Coal Measures, or "Ganister Beds."
	Millstone Grit.
	Yoredale Rocks.
	Carboniferous, or Mountain Limestone.

Both these Memoirs are well illustrated with sections and diagrams. The authors give due credit to other observers who have previously described these districts. They will be found of the greatest service to all who may need to consult them, either for professional purposes or as amateur geologists.

In November, 1867, the Rev. Thomas Wiltshire, M.A., F.G.S., read a highly interesting paper before the Geologists' Association, "On the Chief Groups of the *Cephalopoda*." This has just been published, and will be found very useful by the student. The author touches upon the structure and habits of these animals, and gives schedules of the recent and fossil Cephalopods, wherein are analyses of the families and genera; he also gives an appendix on the range of the genera in geological time.

Mr. E. D. Cope has published the first part of an elaborate 'Synopsis of the extinct Batrachia and Reptilia of North America.' He has thought it best to describe only those species and types which are new, and those portions of imperfectly known forms which will throw additional light on their relations and affinities.

In the course of his investigations, prosecuted during the past six years, with reference to the structure and relations of the extinct Reptilia, the following general conclusions have been arrived at, besides many of lesser significance:—

1. That the *Dinosauria* present a graduated series of approximations to the birds, and possess some peculiarities in common with that class, standing between it and the *Crocodilia*.
2. That serpents exist in the Eocene formations of this country.
3. That the *Chelydra* type was greatly developed during the American Cretaceous period; and that all the supposed marine-turtles described from it are really of the first-named group.
4. That the *Reptilia* of the American Triassic period are of the *Belodon* type.
5. The discovery of the characters of the order *Pythonomorpha*.
6. The discovery of the characters of the order *Streptosauria*.
7. The development of the characters of numerous members of the Batrachian sub-order *Microsauria* in the United States.

The Memoir is illustrated with eleven plates and numerous woodcuts. Mr. Cope's work is peculiarly interesting, as bearing upon the researches of Professor Huxley on the affinities of the *Dinosauria* with the class *Aves* independently carried on in this country.

'The Geology and Mineral Veins of the Country around Shelve, Shropshire, with a Notice of the Breidden Hills,' by G. H. Morton, F.G.S., F.R G.S.I., President of the Liverpool Geological Society (extracted from the Proceedings of the Society), Liverpool, 8vo, pp 41.

This work treats of both the Geology and the Archæology of

Shelve, which is situated in western Shropshire. The lead mines were worked in the Roman period, as shown by their coins, pottery, and mining implements; pigs of lead bearing on their stamp the name of Hadrian have been found there. The remains of Roman encampments exist in the neighbourhood, as well as several Druidical circles; the largest of which, the Circle, or "Hoar stones," has still thirty-two stones standing, and seems originally to have contained thirty-six.

Very red copper ore, "Redruthite," has been found in the neighbourhood, but workings have only lately been commenced. The average direction of the greatest number of the veins is W.N.W. by E.S.E.; most of them are simply fissures in the rock (Lower Silurian), which is prominently developed in this district, filled with Barytes Calcite and irregular strings and nests of Galena and Blende, interspersed with fragments of the slate-rock. The author observes, "It is remarkable that in the Upper Llandeilo rocks the veins principally contain *Barytes*; the Lower Llandeilo rocks, *lead*; and the Cambrian rocks, *copper*."

There are several interesting sections given, showing the disturbances caused in the Lingula flags, Llandeilo and Cambrian beds, &c., by the eruptive intrusion of greenstone and other trap-rocks. Lists of the fossils found in these formations and maps of the mineral veins are also appended.

The Breidden Hills, about ten miles N.W. of Shelve, range to the height of 1200 feet above the sea-level, are surrounded by the Llandeilo strata, and are interesting from the many varieties of porphyritic and amygdaloidal greenstone, trap-breccia, and ash, of which they are composed.

The 'Geological Magazine' for October, November, and December contains an abundant supply of interesting papers, only a few of which we have space to notice.

1. A novel theory of the formation of the Chesil Bank is propounded by Messrs. H. W. Bristow and W. Whitaker. The question they deal with is simply the cause of the position of the beach, separated as it is from the mainland throughout its greater length by a strip of water called "the Fleet."

The authors are of opinion that this channel was formed subsequently to the heaping up of the shingle, which they think was originally formed against the land. East of Abbotsbury the ground is comparatively low, and numerous streams run into the Fleet; while for some distance west of this village there are no streams, the ground is much higher, with cliffs, and the beach is not separated from the land. The conclusion arrived at is that after the beach was formed against the land, these streams in flowing down towards the sea would turn eastwards for some distance before filtering through the shingle (as is the case with streams west of Burton

Bradstock), and as they are not far apart they would in time meet and form a continuous channel (the Fleet), which would be widened and kept clear by land-waters, aided perhaps by tidal action as suggested by Mr. Evans.*

2. Mr. Ray Lankester records the discovery of *Machairodus* in the Forest-bed of Norfolk; and from the researches of Mr. Pengelly, no doubt can remain that the great sabre-toothed tiger should be retained on our list of British Fossil Mammals.

3. Professor Owen describes two new Ichthyodorulites, *Lepracanthus Colei* from the coal-shale of North Wales, and *Hybodus complanatus* (of Neocomian age) from the Iguanodon quarry of Mr. Bensted, at Maidstone.

4. The Rev. T. G. Bonney discusses the origin of some supposed "Pholas-burrows" in the Ormesheads. He is inclined to attribute these holes (with Dr. Buckland and M. Bouchard-Chantereaux) to the agency of land-snails, probably *Helix aspersa*; but we expect that many will still think it safer to regard them as due to atmospheric influences, and that subsequently snails have taken up their abodes in the hollows.

5. Mr. C. E. De Rance writes on the Surface-Geology of the Lake District.

6. Dr. H. A. Nicholson describes some plant-remains from the Skiddaw slates, and Mr. Henry Hicks some still older from the Arenig beds of St. David's.

7. Dr. Ruskin continues his researches on Banded and Brecciated Concretions.

8. Mr. Scrope combats some of Mr. Mackintosh's statements of the marine origin of certain terraces, popularly called "Lynchets" or "Balks." These he regards as of artificial origin, to be owing to the disturbing action of the plough and the mattock on the surface-slopes, aided by downward rain-carriage of the loosened soil—a process which, he adds, is *visibly* going on wherever a hill-side is under cultivation.

9. Professor Harkness contributes a paper on the Middle Pleistocene Deposits, having reference to the beds in England, Scotland, and Ireland.

10. Mr. R. Tate furnishes some notes on new and little-known Liassic Brachiopoda, and gives a table showing the distribution of all the species known to occur in the Lias of Britain.

11. The Earl of Enniskillen, following Sir P. Egerton's example, supplies an alphabetical catalogue of type-specimens of Fossil Fishes in his collection at Florence Court, which he also adds are open to the inspection of any geological or palæontological student.

12. Mr. W. H. S. Westropp notices the occurrence of Albite in the granite of Leinster.

---

* When this paper was read at the Geological Society's meeting.

We regret to record the death of Dr. R. N. Rubidge, F.G.S., &c., a gentleman well known for his investigations into the geology of South Africa.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF LONDON.

The 100th No. of the Society's 'Quarterly Journal' is now before us. It is hardly so bulky as usual, for besides two postponed papers it only contains the communications read at one (the last) meeting of Session 1868–9, and very many of them are merely published in abstract. One of these papers is by Mr. Whitaker, and the subject—"The Connection of the Geological Structure and Physical Features of the South-east of England with the Consumption Death-rate"—is a comparatively new and a very important one.*

We will briefly notice one or two of the papers contained in this Journal.

Sir Philip Egerton, Bart., describes two new species of *Gyrodus:* one from the Middle Oolite on the east coast of Sutherlandshire; the other, several specimens of which exist, is from the Kimmeridge clay of Kimmeridge.

Mr. J. W. Hulke, F.R.S, contributes two papers. In the first he describes a large Saurian humerus from the Kimmeridge clay of the Dorset coast. A careful examination and comparison of it with other reptilian remains show it to possess strong crocodilian affinities, but to differ from any genus yet completely known. That to which it appears most closely related is a bone (now in the British Museum) upon which Dr. Mantell founded his genus *Pelorosaurus*. The immense size of the Saurian to which this humerus belonged may be judged from the bone measuring 31 inches in length, and the girth of the shaft near the middle being 11 inches. In the second paper, Mr. Hulke furnishes notes on some fossil remains of a gavial-like Saurian from Kimmeridge Bay, wherein he establishes its identity with Cuvier's "Deuxième Gavial d'Honfleur" (*Steneosaurus rostrominor* of G. St. Hilaire), and with Quenstedt's *Dakosaurus*.

Mr. W. T. Blanford, F.G.S., who was attached as geologist to the Abyssinian expeditionary force, here brings forward some of the results of his observations while acting in this capacity. Recent and Post-Tertiary, Tertiary, Cretaceous, Jurassic, and probably Triassic rocks, are represented in Abyssinia. Many fossils were collected, and Mr. Etheridge remarked on the similarity of the Oolitic specimens to those from the Cotteswold Hills, and also to some from the Holy Land. In speaking of the denudation to which the country has been subjected, Mr. Blanford stated that there were no marks of glaciation discernible, the excavation of the valleys being apparently due to the excessive rainfall. There was not a trace of marine denudation over the surface examined.

---

* This paper has appeared in the 'Geological Magazine.'

Mr. Mackintosh, F.G.S., contributes an interesting paper "On the Correlation, Nature, and Origin of the Drifts of North-west Lancashire and a part of Cumberland, with remarks on Denudation."

Mr. J. Wood Mason, F.G.S., describes a new Acrodont Saurian from the Lower Chalk, near Folkestone, to which he assigns the name *Acrodontosaurus Gardneri.*

Mr. Searles V. Wood, jun., F.G.S., and Mr. F. W. Harmer, bring forward evidence of a peculiar case of intra-glacial erosion near Norwich.

Their observations tend to show that after the deposition of the uppermost bed of the Lower Glacial period there was a physical break, a suspension of deposit, during which lapse of time an erosion took place, sweeping out some of the glacial beds already formed, and extending some way into the Chalk beneath. Into the trough thus formed the succeeding drifts of Middle Glacial age were deposited, as well as upon the hills in regular order above those Lower Glacial beds unaffected by the denuding agency. A section exhibiting these phenomena has recently been disclosed by some new drainage works at Norwich, which the authors hoped by their communication to induce geologists to visit. Some little time ago, Mr. Harmer described to the Society a "Third Boulder-clay" which he found lying in the bottom of the Yare valley. This may now be explained from the section described in the present paper; the authors are inclined to regard it as a portion of the Great (or Upper) Boulder Clay, which was deposited at this low level owing to the intra-glacial erosion which had taken place before its deposition.

Mr. J. W. Flower, F.G.S., records some recent discoveries of flint implements in the drift of Norfolk and Suffolk, concluding with some observations on the theories accounting for their distribution. The distribution of the drift-beds he is disposed to attribute, with the French geologists, to some powerful cataclysmal action, perhaps of short duration, and several times repeated,—an opinion in which it appears but few of our own countrymen coincide.

8. METEOROLOGY.

The sudden change of weather noticed in the note to our last Chronicle, p. 549, forms the subject of an interesting paper in the last number of the 'Journal of the Scottish Meteorological Society.' This change occurred in the afternoon of the 28th of August. The preceding days had been exceptionally warm, especially in

England; but on that evening a current of polar air began to flow southwards, causing a fall of temperature of 40° within ten or twelve hours at several stations (35° at Marchmont Dunse in seven hours), and producing the unusual phenomenon of a smart night-frost before the end of August.

The same number of the journal contains a paper by Mr. Milne Home "On Rotatory Storms," which he seeks to explain by the analogy of other known atmospherical disturbances. The paper, which is well illustrated, consists of a series of extracts from the reports of various observers of waterspouts and whirlwinds which they have witnessed, and from Dr. Baddeley's work on the Dust-storms of India. The reasoning on the data thus collected is very brief, and not altogether satisfactory. Mr. Home assumes that all our ordinary storms are simply gigantic whirlwinds, generated by some unknown agency, probably the friction of interfering air-currents at a high level in the atmosphere. Two such currents would generate a vortex of conical shape, with great barometrical rarefaction in the centre, of which the point may reach the earth, and produce a reduction of pressure and a great disturbance of the atmosphere. There are, however, several flaws in this chain of reasoning, not the least important of which is the attempt to explain the sudden fall of temperature in the rear of the storm, which accompanies the north-west wind felt there, by the supposition that the centrifugal force of the vortex throws out a mass of heated air into the upper region of the atmosphere, and thereby displaces the colder strata at that level, forcing them down to the ground.

A more important paper on a cognate subject is Mr. Blanford's investigation as to the origin of the Calcutta cyclone of Nov. 1, 1867, which appears in vol. xvii. of the Royal Society's 'Proceedings.' Mr. Blanford is led by the data he has collected to the belief that the cyclone was generated on Oct. 27 in the neighbourbood of the Nicobar Islands. For a day or two previous there had been a barometrical depression at that point, when three distinctly-marked wind-currents commenced flowing round it, and ultimately coalesced to form the cyclone.

If this idea be true, it would tend to show that the origin of the barometrical depression, the nucleus of the storm, was to be sought for in some agency independent of the mutual action of the wind-currents, a result apparently at variance with the general tendency of Mr. Meldrum's investigations into the analogous storms of the South Indian Ocean, which appear to indicate, as already remarked by us, that the barometrical depression is generated between pre-existing currents of air which subsequently form tangents to the cyclone.

The Report of the Meteorological Committee for Calcutta for

1868 has just appeared, and it shows that Mr. Blanford is getting his work well in hand, and gives a fair promise of future good results.

The next number of the 'Proceedings' (No. 114) contains a paper by Sir E. Sabine, "On the Results of the First Year's Performances of the Photographically Self-recording Instruments at Kew." The mean values for the several elements are compared with those obtained by discussion of the observations for Nertschinsk and Barnaoul, published by Kupffer, and the results are very interesting, as showing the contrast between insular and continental climates.

In connection with Siberia, we may notice that a brief account of the climate of Sitka and the adjacent country is to be found in vol. viii. of the 'Transactions of the Swedish Academy,' recently published. It is in German, and is contained in a letter from Herr Furuhjelm, of Helsingfors, who lived in that colony for many years. Little was known of its climate before; and what we now learn of it shows that "Walrussia" is anything but an enviable place of residence, owing to its excessive dampness.

Professor Wild, the new Director of the Central Physical Observatory at St. Petersburg, has lost no time in bringing out the volume of 'Annales' for 1865, the issue of which had been interrupted since the death of Kupffer. He tells us in the preface that a complete change will soon be made in the form and contents of the publication. The metrical scale is to be at once introduced throughout the empire, and the speedy adoption of self-recording instruments is announced as probable.

The Journal of the Austrian Meteorological Society contains a very interesting account, by Abich, of two hail-storms experienced at Tiflis in May last. The stones, which were of great size, were crystallized in forms well known in mineralogy. How these stones remained suspended in the air long enough for crystals of such size and regularity to be formed is a question which Abich does not attempt to solve. It is most fortunate that the occurrence came under the notice of so able a mineralogist as he is, and we hope that it will find its way into some of our geological journals. The connection between meteorology and physical geology is close enough, but a bond of union between it and mineralogy is at least unexpected.

Herr von Freeden has brought out No. 2 of the 'Mittheilungen' of his office, the weather calendar for North-west Germany, being a discussion of his own observations carried on for ten years at Elsfleth, near Bremen. The whole treatment of the subject is very thorough, and the paper is a most useful one, as a record of what may be effected by a single observer keeping a registry for a long period on a definite system. There is one special table which calls for notice, that of the daily temperature of the river Weser. The results tend to set at rest the moot question of the relation between water and air temperature. They show that while the water was permanently warmer than the air to the extent of 3°·5 F. on the mean of the year, its changes followed those of the air in point of time, but were less in extent. There are several very suggestive deductions from the tables, and the calendar concludes with some useful practical weather rules.

We mentioned lately that M. Coumbary had organized a Meteorological service in the Turkish empire. He has now begun to publish a monthly *résumé* of his observations. The provincial stations from which returns for September are published are: Smyrna, Beyrout, Diarbekir, Bagdad, Fao, Rustchuk, Sulina, Varna, Trebizonde, and Salonica. M. Coumbary is very anxious to obtain daily telegraphic reports from Bombay, an idea even more novel than that which is already an accomplished fact, the regular daily service across the Atlantic.

The 'Bulletin' of the new central observatory at Montsouris, near Paris, has now assumed a definite shape as regards its contents. It gives for the observatory eight readings daily of the various instruments, with reports of the state of the atmosphere and the amount of cloud. Observations are also printed from some stations near Paris, as well as from six stations on the coast, the same as are published in our own 'Daily Weather Report,' and the daily summary of British weather supplied by telegraph to the Ministère de la Marine is appended.

Le Verrier's 'Atlas Météorologique' for 1868 contains, in addition to the usual charts and accounts of the thunder and hail storms, and a general sketch of the rainfall in France during the year, a number of memoirs of very varied scope. Among them we find one by M. Rayet, on the climate of the Isthmus of Suez; another, by M. Belgrand, on the rainfall in the Seine basin at the Quaternary epoch (this latter might almost as suitably find a place in the 'Journal of the Geological Society'); and a number of special notices from the various departments. There is, however, a paper by Mr. Buchan, "On the Meteorology of North-west Europe in 1868," which calls for remark. The author is well fitted for the preparation of such a paper by his experience in studying storms; but in our opinion the value of his reasoning is much diminished by the introduction of too much theory. More than once we have a long train of argument depending on a succession of "ifs." This is not logical reasoning at all, and is rather out of place in a paper like that we are discussing. This tendency to theorize we have before had to notice in Mr. Buchan, as a blemish on his work. Let us have the facts discussed honestly, and few can do that better than he can; but let the theories be kept to be aired before scientific societies and published in their journals. Meteorology has suffered more than most sciences from building castles in the air. Let us lay a firm foundation before we begin the structure.

9. MINERALOGY.

"Here there is no room for might, could, would, or should,—but it *is* so; *native lead* in melaphyre!" With these confident words Dr. Zerrenner introduces to us the discovery of native lead imbedded in a rock at Stüzerbach, in Thuringia.* And, in truth, his expressions of assurance are by no means ill-timed; for there is confessedly a little scepticism lurking in the minds of many of us as to the genuineness of such a find—scepticism which is perhaps pardonable enough when we remember how often the mineralogist has been bitten by describing old shot and rifle bullets as natural productions! In the case before us, however, there seems no reason to think that Dr. Zerrenner has misplaced his confidence—judging at least from the illustration which shows the globules of lead imbedded in the cavities of the amygdaloidal melaphyre, and more especially from his description which refers to it as running through the rock in strings.

Native lead is also said to have been found, within the last few years, associated with gold in the auriferous drifts of some of the deep mining "leads" in Victoria.† Quite recently, too, we have seen some reputed native lead in the form of rounded shot, coated with a whitish incrustation, and accompanied by magnetic iron-ore and native gold, from the old auriferous district in Co. Wicklow.

On a question so obscure and enigmatical as that of the origin of the diamond, every tittle of evidence is worth recording. Dr. Göppert, in his famous essay which gained a prize at the Haarlem Academy in 1864, argued strongly in favour of the formation of this mineral by the wet way. He now publishes an account of certain diamonds containing organic structures tending to confirm his views.‡ Two diamonds in the Royal Mineralogical Museum in Berlin were found to enclose numerous green cells closely resembling those of many algæ. One of the diamonds, weighing 263 milligrammes, contains a very large number of perfectly round green granules, which appear to be isolated cells not unlike those of *Protococcus pluvialis.* The new species is accordingly named *P. adamantinus.* In the second diamond, weighing 345 milligrammes, the cells are less round and more elongated in form, while they frequently unite so as to form a loose parenchymatous tissue: they find their best representatives in *Palmogloea macrococca,* and Göppert has accordingly ventured to name the new diamond-plant *Palmogloeites adamantinus.*

---

* 'Berg und Hüttenmännische Zeitung,' No. 12, 1869, p. 105; also, 'Mineralogische Nachrichten,' 1869, p. 33.

† 'The Gold-fields and Mineral Districts of Victoria.' By R. Brough Smyth. Melbourne, 1869. Pp. 420.

‡ 'Ueber algenartige Einschlüsse in Diamanten, und über Bildung derselben.' Abhandl. d. Schlesisch. Gesellsch. (§ Naturwiss. u. Medicin), 1869, p. 62.

Once again, the old mistake has been repeated in Australia. In the New England district a stone was found, about the size and shape of a duck's egg, and weighing 6 oz. 13 dwts. 12 grs. troy. Of course it was taken for a diamond, and rumour was soon rife as to its prodigious worth. A few days after announcing the discovery, the 'Australian Mail' coolly adds, "The 'great diamond' which had created so much sensation has proved to be a piece of crystal-quartz!"

Hitherto crystallized quartz has been artificially prepared only by wet processes. But the presence of this mineral in rocks usually referred to an igneous origin, naturally leads to the belief that it may certainly be produced also in the dry way. Acting on this belief, Gustav Rose has recently experimented on the fusion of silica, adularia, and other minerals, in salt of phosphorus and in borax.* His experiments were conducted on a large scale at the furnaces of the Royal Porcelain Manufactory at Berlin. Crystallized silica was thus obtained, but in the form of small six-sided plates, unlike the crystals of common quartz, from which it also differed in having the low density of 2·3. Rose has thus produced not ordinary quartz, but Vom Rath's curious new species Tridymite, which has been already described in this Journal. Whilst he has thus obtained artificial tridymite, he does not despair of forming artificial quartz by a modification of his process.

Spectrum analysis has been applied, by Vogelsang and Geissler, to the difficult question of determining the chemical nature of the fluid found enclosed in minute quantity in the cavities of certain quartz-crystals.† Fragments of quartz were placed in a small retort, which was connected with an air-pump and exhausted; then by the application of heat the quartz decrepitated, and the evolved vapour was examined in a Geissler-tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime-water.

Among some minerals examined by Herr Petersen from the St. Wenzel mine, near Wolfach, in Baden, he finds a new species belonging to the interesting group of antimonial sulphides of silver.‡

---

* 'Monatsbericht d. k. preussichen Akad. d. Wiss.,' 1869, p. 449.

† 'Rhein Verhdlg.,' xxv. Sitzungsber, p. 77.

‡ Poggendorff's 'Annalen,' No. 7, 1869, p. 377.

The new mineral is to be called *Polyargyrite* or *Weichglaserz.* It occurs in small iron-black crystals, belonging to the cubic system, and consisting of 12 $Ag\,S + Sb\,S_3$. Now that we are acquainted with another member of these antimonial sulphides, it may be well to compare the composition and crystalline system of these minerals, since it is hardly probable that another species of this group will be found containing more silver sulphide than is present in polyargyrite.

Miargyrite	$Ag\,S + Sb\,S_3$	oblique
Pyrargyrite	$3\,Ag\,S + Sb\,S_3$	hexagonal.
Stephanite	$6\,Ag\,S + Sb\,S_3$	rhombic.
Polybasite	$9\,Ag\,S + Sb\,S_3$	hexagonal.
Polyargyrite	$12\,Ag\,S + Sb\,S_3$	cubic.
Argentite	$Ag\,S$	cubic.

Another new mineral from the same locality is described under the name of *Wolfachite.* It crystallizes in the rhombic system, and contains:—$Ni\,S_2 + Ni\,(As_2\,Sb_2)$.

English ears will not easily get reconciled to the sound of *Wollongongite*—the name which Professor Silliman proposes for a new native hydrocarbon, which promises to become of great technical importance.* It seems to be a variety of cannel, occurring abundantly in the Wollongong district of the Illawarra coal-field in New South Wales. On distillation it yields a large volume of gas of remarkably high illuminating power.

A mineral mistaken for augite has lately been found by Professor Brush to be a new variety of chrysolite, and he has accordingly named it *Hortonolite,* in recognition of Mr. Silas Horton's courtesy in calling his attention to it.† It occurs in the form of dull blackish rhombic crystals, in the iron mine at Monroe, Orange Co., New York; and from its abundance it may become of some commercial importance as an iron-ore. It is chemically a chrysolite, containing iron, magnesia, and manganese.

Among the fine pebbles of stream-tin from Durango, in Mexico, it is well known that the mineralogist finds the most beautiful little crystals of limpid topaz. With these there have lately been detected certain oblique crystals of an orange-coloured mineral, which Professor Brush names after the locality.‡ The following is the general formula of *Durangite,* where the protoxides are soda and manganous oxide, whilst the sesquioxides are alumina and ferric oxide: $\{\tfrac{1}{4}\,(3\,RO) + \tfrac{3}{4}\,(R_2\,O_3)\}\,As\,O_5$. Fluorine is also present in this mineral, but its quantity has not been determined. It is said that Durangite is the only native "fluo-arsenate" which has hitherto been observed.

Professor Brush has also lately published the analysis of a meteoric stone which fell near Frankfort, in Franklin Co., Alabama, on the 5th December, 1868.[*]

---

* Silliman's 'American Journal of Science,' July, 1869, p. 85.

† Ibid., p. 17.

‡ Ibid., Sept., 1869, p. 179.

Attention has again been called to the occurrence of pseudomorphs in Bunter sandstone after scalenohedra of calcite.[†] The discoveries of Dr. Blum, already noticed in this Journal, have been supplemented by those of Dr. Klocke, from which it appears that the pseudomorphs occur in several new localities in the neighbourhood of Heidelberg.

A new mica, related to biotite and phlogopite, has been described by Von Kobell under the name of *Aspidolite*, in allusion to the basal face of the crystals often resembling an oval shield (*ἀσπίς*). The crystals are small rhombic prisms, of a dark olive-green colour, and are found in the chlorite of the Zillerthal in Tyrol.[‡]

So complex is the chemical constitution of that curious mineral, the *Tourmaline*, that Mr. Ruskin not unaptly calls it "more like a mediæval doctor's prescription than the making of a respectable mineral." In spite of its complexity, Rammelsberg has lately succeeded in reducing all his analyses of this substance to the general type of the silicate $R_6\ Si\ O_5$, where R is considered monatomic, and may represent six atoms of any of the monads hydrogen, potassium, sodium, and lithium; or three atoms of the dyads magnesium, calcium, manganese, and oxygen; or two atoms of the triads boron and aluminium.[§] All tourmalines fall into two sections—one represented by the general formula $R_3\ Al_2\ B\ Si_2\ O_{10}$, which is, of course, obtained by doubling the molecule above; whilst the second section contains nine of these molecules written thus:—$R_6\ Al_{12}\ B_4\ Si_9\ O_{45}$.

Rammelsberg has also published a chemical note on the constitution of Axinite, and on some native compounds of tantalium and niobium.[‖]

Some good crystals of *Gadolonite*—the mineral in which yttria was first discovered—have been examined by M. Des Cloiseaux.[¶] He finds the crystals from Hitteröe to be doubly refracting, and to contain from 10 to 12 per cent. of glucina; while those from Ytterby are singly refracting, and contain no glucina.

Dr. Sadebeck, of Berlin, whose examination of the crystalline forms of copper-pyrites has already been referred to in this Journal, has lately directed his studies to another common mineral *zinc-blende*, and has produced an elaborate paper on the hemihedral forms of this cubic mineral.[**]

---

[*] Silliman's 'American Journal of Science,' Sept., 1869.

[†] Leonhard und Bronn's 'Jahrbuch,' No. 6, 1869, p. 714.

[‡] 'Sitzungsberichte d. K. bay. Acad. d. Wissenschaften,' 1869.

[§] 'Monatsber. d. k. preuss. Ak. d. Wiss.,' 1869, p. 604.

[‖] 'Zeitschrift d. deutsch. geol. Gesell.,' No. 3, 1869, pp. 555, 689.

[¶] 'Annales de Chimie et de Physique,' Nov., 1869, p. 305.

[**] 'Zeit. d. d. geol. Gesell.,' 1869, No. 3, p. 620.

Whilst we have no lack of literature on the geology of the volcanic district of Auvergne—of which the excellent works of Scrope and Lecoq may be cited as conspicuous examples—there has hitherto been but little written on the mineralogical, chemical, and microscopic structure of the many and varied rocks of that country. It is true that a few of these rocks have been carefully described in the memoirs of Kosmann and of Zirkel, but it has been left for Dr. Lasaulx, of Bonn, to offer us the results of a systematic course of "Petrographic Studies on the Volcanic Rocks of Auvergne."[*] The first part only has yet appeared, and this is devoted to a description of certain of the Auvergne lavas, so that we must look to the continuation of the memoir for a notice of the basalts, trachytes, melaphyres, and phonolites of this interesting locality.

10. MINING AND METALLURGY.

MINING.

THE completed returns of the mineral produce of the United Kingdom for the year 1868 have been published in the 'Mineral Statistics.' The following are the results:—

	Quantities.	Value.
	Tons.	£
Coal	103,141.157	25,785,289[†]
Iron Ore	10,169.231	3,196,000
Tin Ore	13,953	770,205
Copper Ore	157.335	642,103
Lead Ore	95.236	1,150,768
Zinc Ore	12.781	39,191
Iron Pyrites (Sulphur Ores)	76,484	53,636
Gold Quartz	1,191	1,000
Arsenic	3,300	9,710
Gossans and Ochres	6,692	6,372
Wolfram	9	67
Fluor Spar	60	42
Manganese	1,700	7,650
Barytes	14.235	8,728
Coprolites	37,500	71,500
Salt	1.513,840	927,227
Clays, *fine* and *fire*	1,012,479	317,770
Earthy Minerals, various (*estimated*)	.. ..	650,000
Total value of the Minerals produced in the United Kingdom		£33,637,558

---

[*] Leonhard und Bronn's 'Jahrbuch,' No. vi., 1869, p. 641.

[†] Calculated at the actual cost of raising, before any charges for movement are added.

METALS OBTAINED FROM THE ORES ENUMERATED.

	Quantities.	Value.
	Tons.	£
Iron, Pig	4,970,206	12,381,280
Tin	9,300	901,400
Copper	9,817	761,602
Lead	71,017	1,378,404
Zinc	3,713	75,435
	Ounces.	
Silver	835,542	229,773
Gold	1,012	3 522
Other Metals (*estimated*)	.. ..	5,000
Total value of Metals produced	.. ..	£15,736,416

ABSOLUTE TOTAL VALUE of the METAL and COAL, with other MINERALS (not including Slates, Lime, Building Stones, or Common Clays), produced in 1868.

	£
Value of the Metals produced from the Mines of the United Kingdom	15,736,416
Value of COAL	25,785,289
Other Minerals, not smelted, including Salt, Barytes, &c., &c.	2,003,819
	£43,525,524

For two years the sad depression of Cornish mining has been the reiterated complaint. This happily has given place to great activity. The tin mines of Cornwall were never producing more tin than at present, and the prices are such as enable most of the mines to give a good dividend, after paying all the working expenses. The long celebrated Bearhaven mines, in Ireland, which produced (in 1868) 3837 tons of copper ore, are about to change hands, and will for the future be worked by the Mining Company of Ireland.

A variety of experiments have of late years been made in our mines and quarries with explosive compounds of various kinds, with very varied degrees of success. Attention is now called to "Poudre d'ammoniaque," which has created quite a sensation in some of the Continental mines. The following extracts will convey nearly all the information, of value, at present available.

The 'Militäi-Wochenr-Blatt,' of Berlin, says:—"Some time ago the proprietors of the powder manufactory of Nora-Gyttorp took out a patent in Sweden for the invention of the 'poudre d'ammoniaque,' a substance only employed hitherto in a few mining districts, and which seems to be completely unknown elsewhere. Its explosive power may be compared to that of nitro-glycerine, and, consequently, surpasses that of dynamite. It will not explode with a flame or with sparks, but explodes by a powerful blow with a hammer. Chambers charged with this powder have been burst by means of a cartouche of ordinary powder. One of the useful and important properties of this new powder is that it does not require to be heated in cold weather, whilst it is necessary first to heat nitro-glycerine and dynamite, which operation has caused many accidents. According to the information we have received, the "poudre d'ammoniaque" was invented by Norbin, the chemist. The 'Journal of German Public Works' contains extracts from the report of the Prussian architect, Steenke, amongst which are the following remarks concerning poudre d'ammoniaque:—"Experiments have been made by attaching a lamp to a pendulum, and causing it to oscillate. Powder, gun-cotton, nitro-glycerine, and dynamite ignited the moment the flame passed beneath them, but poudre d'ammoniaque only commenced to burn when the flame had touched it twenty times.

"Making experiments to ascertain the pressure requisite to explode it, it was found that, with the instrument employed, explosion followed when the weight descended from 4·5 ft. to 5·5 ft. with powder, 1·6 ft. to 2·25 ft. with nitro-glycerine, 3 ft. to 3·3 ft. with dynamite, and from 13·125 ft. to 14·2 ft. with poudre d'ammoniaque."

The production of gold in Australasia, according to the quarterly returns issued by Mr. R. Brough Smyth for Victoria, and the reports from other quarters, continues to be almost as large as ever.

The quantity of gold exported from Victoria to the 10th of September was 1,145,170 ounces, of which 154,075 ounces were from New Zealand. Very remarkable things are said of the gold fields of the latter place. Some of the quartz, broken from the reefs, or veins, have yielded in recent crushings 30 per cent. of gold. Mr. R. Brough Smyth's book on gold mining will be noticed hereafter.

The want of scientific knowledge amongst our miners is shown in a curious way by some statements which have lately appeared in 'The Mining Journal' on "The Prosperity of Mexico." The "Correspondent" informs us that some curious stones have been discovered at Tula del Hidalgo, "which present a great variety of appearances, and each face has received, and is constantly receiving, *the landscape in front of it, by means of a colour so perfect, that* I believe that art itself cannot produce such relative exactness." Again, we are told, "The faces which begin to receive the first impressions only present the images of the nearest trees with a wonderful perfection and beauty; those that have been in one position for a long time without variation present the complete landscape within the visible horizon, and even the most distant mountains by which it is limited." We perceive in this description a great want of the habit of observation, and a considerable display of "Our Correspondent's" fancy. It will be evident to every one, possessing the slightest knowledge of Mineralogy, that the stones so vividly described are only examples of that mimic vegetation often so beautifully displayed in stones by the oxide of manganese. Those arborescent forms and shaded outlines will be familiar to many who have visited the heights of Clifton, where the "landscape marble," as it is called, is nicely polished and sold to the many visitors to that delightful locality.

'La Houille,' a French journal devoted to the colliery interests of France is, from, the excellence of many of the articles contained in it, commanding a considerable amount of attention. It has recently given some notices of experiments made by MM. Rouille and Co., on producing a light for mines by atmospheric air, impregnated with petroleum vapour by being passed through the more volatile of the coal-shale oils, or other hydro-carbons. We refer to this only to condemn it. In the first place, the introduction of volatile hydro-carbon vapour into a coal mine is only adding another to the many dangers by which the coal miner is surrounded; and in the second place, the process has been long known, often tried, and it has always failed; because the vapour of the petroleum is speedily deposited from the air, and at a comparatively short distance from the reservoir the air ceases to be inflammable.

Our 'Colliery Guardian' calls attention to the "Lighting of Mines" with common gas, by an apparatus devised by Messrs. Church and Co. We are told that the light is produced by the combustion of a mixture of ordinary carburetted hydrogen gas with atmospheric air in certain proportions, and that from the manner in which the combined fluids are consumed *no flame is produced.* We have not seen this lamp. We do not know how the mixture of air and gas is burnt; we presume from the description given that we have a modification of the well-known Oxyhydrogen Lamp—something of either the Bude-light, or the Drummond-light type. This, however, we do know, that the statement that "no flame is produced" is one which cannot be maintained; and while it tends to deceive those who are not familiar with the laws of combustion, it may prove highly dangerous, by leading the unwary to make experiments in explosive atmospheres, under the idea that where there is no flame there can be no ignition of the surrounding gases. That the flame may not have the character of the ordinary flame of a gas-burner may be true; but the very description given proves that a flame of great intensity is produced by the combustion of the mixed gases.

At the Hayle Foundry, in Cornwall, there have been some experimental trials of a system of pneumatic stamps, which have been witnessed by a large number of practical miners, who are most favourably impressed with the results. The following brief description will, we believe, convey a sufficiently clear idea of the general principles of this machine:—

The battery with which the experiment was tried consisted of six heads, all working in one coffer, contained in a strong cast-iron framing; the crank-axle running in two plummer-blocks, carried on top of side frames, which are 62 inches apart; and the height from ground to centre of axle, 110 inches; the total weight, including everything, 8½ tons. The difficulty to overcome was to give a long and variable stroke of head, with a short and constant throw of crank; this, however, has been accomplished, as with forging hammers, in the following manner:—The upper end of the cylinder is bored, to receive the piston, to a depth of 14 inches; the piston-rod plays air-tight through the cylinder cover, which is screwed metal to metal on the cylinder. The working barrel of cylinder is pierced with two sets of small holes, for the ingress and egress of air, discharging the air behind the piston after it has been once used as an elastic cushion. Suppose the head to be set in motion with the crank in a horizontal position, the piston being in the middle, vertically of the working barrel of cylinder, and midway between the two sets of air-holes referred to. As the crank and attached piston rise, the air is compressed between the piston and cylinder cover, and the cylinder, with stamp-head attached, is forced upwards. When in rapid motion, the elasticity of the compressed air between the piston and cover flings the cylinder, with head, some inches above the range, due to the motion of the crank; on the descent of the piston below the bottom set of holes in the cylinder, the air is compressed in a similar manner, and the cylinder is forced down by the compressed air between the piston and cylinder bottom, until the stamp-head strikes the ore in a coffer-trough; thus, whether the quantity of ore be large or small, the blow is always effective.

At the last meeting of the Midland Institute of Mining Engineers, a discussion took place on the paper read by Mr. A. Lupton, in August last, "On the Use of Hydraulic Machines for Breaking down Coal:"—

On first introducing the subject, Mr. Lupton, with the aid of a number of diagrams, gave the results of several experiments which he made for the purpose of testing the value of the hydraulic machines, including those of Mr. Grafton Jones, Mr. Bidder, and Mr. Chubb. The machine of Mr. Grafton Jones, the principle of which consists in driving a wedge by means of a hydraulic press between two blocks of steel which are rendered incapable of any but lateral movement, by tension-bars connecting them with the press, was tested at the Shipley Colliery, in Derbyshire, where the bed of coal is worked on the long wall system in banks from 80 to 100 yards in length, the coal being 4 ft. 7 in. thick. As much work could be done by it and two men, Mr. Lupton said, in from two to three hours, and as much coal got, as would take two men by the ordinary method from one-and-a-half to two days.

Mr. Bidder's machine was capable of giving any degree of expansion, and, in many instances, is similar to Mr. Jones's, as is also that of Mr. Chubb. The discussion on the paper was a very interesting one, and was taken part in by most of the members present. The great object in introducing such machines for getting coal in mines was stated to be, according to the views of those present, the getting of a maximum quantity of large coal at a minimum cost, and, by doing away with gunpowder, to ensure the greater safety of the workmen. Such being the case, it was considered that every encouragement should be given to the inventors of mechanical power having for its object the getting of coal. The impression with regard to the machines noticed in the paper read was that they were as yet incomplete, but were capable of improvement to an extent at least making their use desirable in many collieries instead of gunpowder, and for producing a larger coal generally.

METALLURGY.

The only metallurgical process which has claimed any special attention during the quarter is the following:—

The Removal of Silicon from Pig-Iron was the subject of an interesting paper read before the Iron and Steel Institute at a recent meeting by Mr. J. Palmer Budd, of Ystalyfera. This process was witnessed in operation by many of the members at the works of Messrs. Bolckow and Vaughan, during the meeting of the Institute at Middleborough. It is claimed for the process that it desiliconises the iron, as tapped from the blast-furnaces, without wasting the iron, and without any extra expense, whatever, beyond the usual cost of the pig; that, in fact, it was more economical to make than pig-iron. Mr. Budd's mode of proceeding is to place a series of iron moulds, similar to those used, before a refinery, as near as convenient to the top hole of the blast-furnace. A paste is made by moistening with water, soft hæmatite ore, which, if gritty, is previously ground, and a bucketful, containing about 60lbs., is thrown into the mould in a semi-liquid state, and spread evenly on the bottom and sides. The mould being quite hot from the previous casting, dries the paste which adheres to the bottom. As much iron as is required from the blast-furnace is then allowed to run over and fill the moulds to the depth of from three-and-a-half to four inches. A great ebullition takes place, jets of flame, of a particularly white colour, burn on the surface, which is assumed to be the combustion of silicon in the oxygen liberated from the hæmatite. It has been proved by repeated analysis that whilst the silicon was 1·00 per cent. in the white cast-iron, it is reduced by this simple process to 0·200 or 0·300 per cent., or from one per cent. to $\frac{1}{500}$th. A cinder is thrown up containing silica, some phosphorus and sulphur. The carbon is hardly at all removed. The appearance of the iron after the process is that of refined metal. The cost of the process is *nil*, as the iron contained in the hæmatite is reduced, and adheres as cast-iron to the bottom of the iron in the mould. There is no sand or coke-dust used, and the refined iron goes clean into the puddling-furnace. The yield in puddling is that of refined iron, about 21 cwt. to the ton of puddled bars. The puddlers like to have one or two pigs of white iron with the metal so refined, as they say it works more liquory, showing that when the silicon remaining is only 0·200 or 0·300 per cent. the charge does not possess the necessary fluidity. The puddling furnace keeps longer in repair, no other fettling is used than hammer-slag, and the former allowance of shearings to make scrap-balls has been discontinued. The men do more regular work, and, like the refined iron, the yields are larger. The puddled iron is of an improved quality, and much liked in the rail mills. A second process is the same in every respect as the first, only that $\frac{2}{5}$ths by weight, and half by bulk, of nitrate of soda is mixed with the hæmatite ore, which is formed into a paste and applied in the same way. With this mixture the ebullition is greater, the flame is of a yellowish colour, showing the ignition of some of the soda. The cinder is thrown up and out of the iron, over which it forms a crust, which can be separated when cold. The iron has a cellular and honeycombed fracture, like metal much overblown. The scoriæ contain sulphur, phosphorus, silica, and soda. The iron works drier and cleaner, and to a better yield than that made by the first process, but should have about one-third of grey pig added to make a very clean and tough iron. The only cost of the process is the nitrate of soda, which in the proportion named comes to about 4*s.* a ton at its present high price.

11. PHYSICS.

Light.—The Rev. Father Secchi has published an account of the spectrum of the planet Neptune; he first refers briefly to his former observations of the spectrum exhibited by Uranus, and then states that the spectrum of Neptune consists chiefly of three lines, or bands, placed near the green line, and that its light is entirely devoid of red; this is confirmed by the colour exhibited by the planet when seen through a telescope, which is a sea-green.

M. Bontemps, the managing director of the celebrated crystal glass works of Choisy-le-Roi, states, in his observations on the colouration of glass under the influence of direct sunlight, that he was led to the following results:—Within three months after having been exposed to sunlight, the best and whitest glass made at St. Gobain is turned very distinctly yellow; extra white glass (of a peculiar mode of manufacture) becomes even more yellow, and gradually assumes a colour known as *pelure d'oignon*; glass containing 5 per cent. of litharge is also affected, but far less perceptibly; crystal glass, made with carbonate of potassa (the other varieties referred to contain carbonate of soda), litharge, and silica, is not at all affected; English plate-glass, made by the British Plate-Glass Company, and exhibiting a distinctly azure-blue tinge, remains also unaffected. The author attributes this colouration, which begins with yellow and gradually turns to violet, to the oxidizing effects of the sun's rays upon the protoxides of iron and manganese contained in glass.

A solution of iodide of potassium is, even when kept in well-closed bottles, slowly decomposed by the action of daylight, and assumes a somewhat yellowish tinge due to free iodine. M. Loew filled a number of glass tubes for about from one-half to three-fourths of their capacity, with a solution of iodine of potassium, and, after having sealed these tubes, exposed them to direct sunlight. Another set of tubes were likewise filled with the same solution, but all air was expelled, and the tubes sealed during and after the solution had been boiling for a considerable time. These tubes were also exposed to the action of direct sunlight; after three or four months' exposure the tubes and contents were examined, those wherein no air at all was left were found to be perfectly colourless, no decomposition of the contents having taken place. As regards the other tubes, the following results are noticed:—(1) Under the influence of light, the oxygen of the air decomposes iodide of potassium, iodine in small quantity is set free, while hydrate of potassa is found in the liquid. (2) This decomposition is limited, and does not even, when a large quantity of oxygen is present, increase, because a portion of the iodine set free enters again into combination with the caustic potassa set free, forming iodide of potassium and iodate of potassa. (3) The testing for ozone by means of a solution of iodide of potassium and starch (or paper prepared therewith) is of no value whatever, unless care has been taken to exclude direct sunlight.

HEAT.—M. Dufour recommends the following process for demonstrating that the flame of a candle is formed of a hollow cone, luminous on the outside only, and dark in the interior. A caoutchouc tube has, at one of its extremities, a gas jet with an almost semicircular slit of .04 metre in depth. The other end of the tube communicates with a reservoir of water placed at a convenient height. Upon a suitable pressure, the water flows out by the slit in the jet, producing a clear sheet. The slit is placed in such a manner that the sheet presents a horizontal surface, and this will easily cut the flame of a candle, showing a perfect section. The hot gases and carbonaceous particles are carried off by the water. On placing the eye above the hollow cone, the luminous wall, &c., can be distinctly seen. Sections may easily be made near the wick or near the point; nothing hinders observation, which may be prolonged at pleasure, and a lens may be used if desired. If a current of air be caused to come out of the slit by bellows, an invisible sheet of air is formed which is also very convenient for making a section of flame. Close observation is quite possible, for the aërial current prevents the heated gases from reaching the eyes, and a lens may be used as in the former case. The flame forms a cone, whose luminous walls are extremely thin, and their size can be plainly seen. A platinum-wire may be introduced across the section; and on being plunged as far as the wick it will remain unreddened in the dark interior of the cone. If a jet of gas produced by a fishtail burner be cut, the luminous fan will be found to consist of two brilliant blades, between which there is a narrow obscure space. The blades are at a greater distance apart, and the dark space is wider towards the end of the fantails; M. Dufour suggests that this method might be of service in the chemical analysis of flames.

Mr. Spence has made public an apparent paradox in the science of heat, whereby he is enabled to raise a higher temperature in certain solutions, by steam of 212° Fahr. He selected a solution of a salt (nitrate of soda) having a high boiling-point—about 250° F. The nitrate of soda was placed in a vessel surrounded by a jacket; steam was let into the intervening space, until a temderature of nearly 212° F. was obtained; the steam was then shut off, and an open pipe immersed in the solution, and steam from the same source was thrown directly into the liquor; in a few seconds the thermometer slowly, but steadily, moved, and minute after minute progressed, until it touched 250° F. This unexpected fact has become to the author of immense practical value. As a corroboration of the theory which seems to explain the apparent paradox, the author finds that the temperatures of his solutions are in the exact ratios of their specific gravities, and have no connection with the temperature of the steam, which never exceeds 212° F.. The greater the specific gravity of his solutions, the higher the boiling-point; and therefore, whatever the boiling-point of the solution in water of any salt, to that point, or nearly, will steam of 212° F. raise it.

The annoyance which arises from the bumping of certain liquids when submitted to distillation or boiling has often attracted the attention of chemists, and various means have been proposed for its prevention. Dr. Hugo Müller, F.R.S., has described a ready means for overcoming this annoyance. In cases where the introduction of any foreign matter into the liquid about to be distilled is undesirable, he indroduces through the cork in the tubulus of the retort a glass tube, which is drawn out to a long capillary tube, and pressed tightly to the bottom of the retort. The upper end of the glass tube is connected by means of an india-rubber tube, with a generator of carbonic acid or hydrogen, or a gas-holder containing air; and whilst the distillation is going on, one of these gases is passed in a slow but continuous current through the liquid. Under these conditions all bumping is avoided, and the distillation proceeds with the utmost facility. For ordinary purposes, however, it is still more convenient to introduce into the liquid about to be distilled a small fragment of sodium amalgam, or, in cases where the liquid is acid, a small piece of sodium-tin. Methylic alcohol is well known to be one of the most difficult liquids to distil, yet on the introduction of a minute piece of sodium amalgam or sodium tin it can be distilled without the slightest inconvenience. The action of sodium amalgam and sodium-tin is due to a minute but continuous disengagement of hydrogen taking place during the process of distillation.

Dr. Hofmann has described an ingenious experiment to show that a body really increases in weight during combustion. A small horse-shoe magnet is hung up at the beam of a balance, sufficiently sensitive to turn with centigrammes; the poles of the magnet are immersed for a moment in levigated iron, when a beard of small particles of iron adheres to the poles; by means of proper weights placed on the scale-pan at the other end of the beam the equilibrium is restored. This having been done, the finely-divided iron is kindled by approaching to it the flame of a Bunsen gas-burner, and continues to burn. While burning, it will be seen that the arm of the balance on which the magnet is suspended considerably deviates from the horizontal position, thus indicating an increase of weight on the side where the experiment is going on. This experiment succeeds best with a magnet of moderate dimensions. The horse-shoe magnet applied in this instance weighed without its armature 210 grms., and can bear a load of 12·5 grms. of iron. When this is altogether converted in magnetic oxide by combustion the increase in weight will be about 4·7 grms.

Dr. Seelhorst has repeated Barrett's well-known experiments of holding in the flame of burning hydrogen gas very well-cleaned glass rods, metals recently cleaned by filing them just previous to the holding in the flame, and has observed the same blue colouration as Mr. Barrett did. But the author is not inclined to ascribe this colouration to the effect of sulphur, which should be so generally spread about in the shape of some sulphate as to produce this colouration. The author, though abstaining from stating any precise cause at all, inclines to the belief that the cooling effect of the cold body held in the flame has something to do with this phenomenon. Perfectly pure hydrogen, burning from a platinum burner, as well as from iron or glass burners, exhibited the phenomenon, when cold bodies, just after having been cleaned by scraping or filing, were held in that flame.

According to M. Baille the moon's surface emits as much heat as a cube filled with water, covered with lamp-black, having a surface of 6·5 square centims., and placed at a distance of 35 metres from the thermo-electric measuring apparatus employed by the author for his experiments.

In a paper "On the Reflexion of Heat on the Surface of Fluor Spar and other Substances," by M. Magnus, we learn that the following substances reflect at an angle of 45° the undermentioned quantities of heat:—silver, between 83 and 90 per cent.; glass, between 6 and 14 per cent.; rock-salt, between 5 and 12 per cent.; fluor spar, between 6 and 10 per cent. The same author finds that different bodies heated to 150° emit different kinds of heat; some substances only emit one kind of heat, others, again, various kinds. Pure rock-salt is mono-thermic, sylvine (chloride of potassium) behaves in a similar manner.

M. Delaurier proposes for concentrating and utilizing the sun's rays, a truncated cone, open at both ends and lined inside with polished silver, the sun's rays being admitted by the largest opening. Since the angle of reflexion is equal to the angle of incidence, all direct or reflected rays will be united at the narrower end of the cone. It is clear that the greater the length of the cone, the greater will be the concentration of heat. The author enters into a discussion on the advantage of this contrivance over the use of lenses and mirrors, and he very enthusiastically surmises that the heat of the sun's rays may be so concentrated as to serve for various purposes instead of the combustion of fuel, especially in countries where, as in Algeria, the heat and splendour of the sun are more permanently felt than it is in our climate.

Electricity.—Our limited space prevents us from doing more than allude to one or two novelties in this science. Dr. Runspaden has published a monograph on a subject first observed by Professor Wöhler, that when water acidified with sulphuric acid is decomposed by a galvanic current, and silver is used as electrodes, peroxide of silver is deposited on the anode, and metallic silver on the cathode. The two main questions answered by the author by a series of experiments are, What is the cause of the formation of peroxide of silver on the positive pole, and by what means does the metallic silver find its way from the positive to the negative pole? In an appendix, the author informs us that there is an error in all works on physics, *viz.* the statement that gold (pure, of course) and platinum are the only two metals which are not oxidized at the positive pole, when serving as electrodes. The author finds, and has confirmed by experiments carefully conducted, so as to exclude any source of error, that gold itself is oxidized to a very considerable extent, and that during such experiments as those alluded to, there is formed a definite oxide,—$Au_2 O_3 3H_2O$; containing gold, 79·47 per cent.; oxygen, 9·62 per cent.; water, 10·91 per cent.

A mode has been devised for depositing copper, silver, or gold by the electric process upon paper or any other fibrous material. This is accomplished by first rendering the paper a good conductor of electricity, without coating it with any material which will peel off. One of the best methods is to take a solution of nitrate of silver, pour in liquid ammonia till the precipitate formed at first is entirely dissolved again; then place the paper, silk, or muslin, for one or two hours in this solution. After taking it out and drying well, it is exposed to a current of hydrogen gas, by which operation the silver is reduced to a metallic state, and the material becomes so good a conductor of electricity, that it may be electro-plated with copper, silver, or gold in the usual manner. Material prepared in this manner may be employed for various useful and ornamental purposes.

12. ZOOLOGY—ANIMAL PHYSIOLOGY AND MORPHOLOGY.

PHYSIOLOGY.

The Origin of the Fibrin of the Blood.—Dr. Heynsius in the course of a series of investigations on the albuminoids of the blood, endeavoured to determine whether any of the constituents of the blood corpuscle contribute to the formation of fibrin. He finds that the quantity of fibrin obtained from the same blood by the same treatment is somewhat variable, owing to the defectiveness of the method. By whipping the blood, a greater amount of fibrin is obtained than by washing the clot. The addition of phosphate of soda to the blood previous to coagulation, causes great difference in the amount of fibrin. In the plasma of the dog, the quantity of fibrin, or of its parent substances (as taught by Buchanan and Schmidt), is certainly smaller than the quantity of fibrinogenetic substance and globulin contained in the blood. In chicken's blood the quantity of fibrin obtained is alone much greater than the quantity of fibrinogenetic substance that can be separated from the plasma diluted with a solution of salt of four per cent. Hence it is not possible to doubt that the albuminoid substance of the so-called stroma of the blood corpuscles contributes to the formation of fibrin. These observations of Dr. Heynsius are of very great value, as they tend further to explain the mysterious process of coagulation of the blood, for although the ammonia theory is abandoned, and Schmidt's view of a fibrinogenetic material in the plasma, and a fibrinoplastic one in the corpuscles, has been taught as the best explanation which could be offered of the phenomenon, yet further details were and are still wanting. It appears now that the corpuscles can furnish fibrinogenetic as well as fibrinoplastic substance.

Whence comes the free Hydrochloric Acid in the Stomach?—Acid phosphates reacting on alkaline chlorides produce free hydrochloric acid. In the capillaries of the stomach, distended by engorgement, acid phosphates are believed by Professor Horsford, of Cambridge, Mass., to be formed, and thus the free hydrochloric acid produced. By dialytic action the hydrochloric acid is rapidly separated from the inner tissue where it is formed, and coming in contact with the epithelial cells of the gastric tubules, bursts and dissolves some of them, thus forming pepsine, which, together with the acid, some phosphates and chlorides, escapes into the stomach to act in the liquefaction of food.

Development of Gas in Protoplasm.—Dr. Th. Engelmann has observed in *Arcella*, a minute protozoon like an *Amœba* with a shell, a periodical development of gas. Dr. Engelmann made his observations on specimens confined in a gas chamber, and describes minutely how gradually in the protoplasmic hyaline substance of the animalcule, black points arise, which as gradually coalesce, forming a distinct air-bubble. This gas can after a time be absorbed again, and reasons are given for believing that a sort of volition is exercised by the *Arcellæ* in the secretion and absorption of the gas which they use in the manner of a float or air-bladder. The air-bubbles are not connected with the contractile vacuoles or with the nuclei. The air-bubbles, it is important to observe, do not occur in the non-granular protoplasm of the pseudopodia, but in the granular substance, and are not spherical but of an irregular form, which, as Dr. Engelmann observes, proves that the protoplasm is not in the condition of aggregation of a fluid. The chemical composition of the gas thus so remarkably developed by the *Arcellæ* was not determined, nor the mechanism (if any exist) of the formation and disappearance of the air-bubbles. The discovery is of importance from two points of view: in the first place, for the development of gas in protoplasm as a physiological phenomenon; in the second place, for the supposed voluntary nature of this development, of which this exceedingly simple organism makes use for the purpose of locomotion. In the 'Cambridge Journal of Anatomy' this paper is noticed very fully by Dr. Moore.

Starch in Muscles.—Nasse has found starch in the muscles, of which he considers it a normal constituent, and believes it to be consumed in muscular action, forming a part of the fuel with which our muscular engines are fed. It is not many years since starch was regarded as a peculiarly vegetable product, and even now it seems difficult to persuade some people that it is not. Bernard's discovery of glycogen, or liver-starch, is, however, sufficiently well known, and so-called "annyloid substance" has been found in many other organs. The starch in muscle is probably connected with the sugar there found, and some time since shown to be connected with muscular activity by Ranke.

The Endings of Nerves in the Liver.—Professor Pflüger, of Bonn, continues his valuable researches on the terminations of nerves in the various glands of the body. By the use of hyperosmic acid applied in a method peculiar to himself, Pflüger has shown that the nerves to the salivary and pancreatic glands end in or as parts of the substance of the secreting cells of those glands. He now shows, in the last number of his 'Archiv,' that this method of termination is found also in the liver. His observations on the structure of the liver generally are confirmatory of Dr. Beale's views, in opposition to some recent German investigators. He speaks of the hepatic cell as a nucleated swelling of the axis cylinder of a nerve. Hence the influence of the nervous system on the secretion of bile, as seen in the well-known influence of mental affections upon it, is rendered intelligible. So, too, with regard to other glands, for Pflüger holds that it is impossible to understand the action of a nerve upon a secreting gland, or upon any other active structure, without the supposition of a continuity of structure between the two, and this continuity he has now demonstrated in the more important glands.

The Secretory Nerve of the Parotid Gland.—Professor Eckhard has, in a recently published essay, given an account of a series of careful researches on the nerves which directly stimulate the secretion of the parotid gland. By various arguments he is led finally to the conclusion, that in dogs the secretory nerve of the parotid is the tympanic branch of the glosso-pharyngeal nerve.

MORPHOLOGY.

Cuckoo's Eggs.—Professor Alfred Newton, of Cambridge, in a recent number of 'Nature' advocates and endeavours to explain Baldamus' views with regard to the eggs of the cuckoo. Baldamus maintained that the popular assertion (popular where?) that the cuckoo lays an egg which varies somewhat in colour according to the nest in which it is deposited,—being modified according to the case, so as to imitate the appearance of the eggs belonging to the nest—is right. This, Professor Newton accepts as a fact, having seen Dr. Baldamus' specimens, and he endeavours to explain this modification of the egg which must otherwise be supposed to be a voluntary act of the bird, by an appeal to the Darwinian theory.

Professor Newton supposes that of a number of eggs laid by cuckoos in the nests of a given species of bird, those eggs would be most likely to come to maturity which, *cæteris paribus*, had the strongest resemblance to the egg of the given species. He further supposes that the offspring would inherit a tendency to lay in the nest of the same species which its parent had imposed upon, and thus there would be established a race of cuckoos infesting the nest of species A, another race infesting B, and so on, each of which races must tend to imitate closely more and more the eggs of the infested species. Mr. Sterland objects to this, that in England no such variety in cuckoos' eggs as that described by Baldamus is seen, and that the hedge-sparrow's blue eggs are those most commonly associated with the utterly different speckled eggs of the cuckoo. He also maintains that the supposed separate races of cuckoo would not be able to keep unmixed, that they must get interbred, but he forgets that the females could only be crossed by males, who may be unable to transmit or affect peculiarities belonging to the females who were their progenitors or happen to be their consorts.

The Kinship of the Vertebrates and the Ascidian Molluscs.—Kowalevsky, a Russian observer, has made some investigations into the development of Ascidians, which are likely to excite more attention than anything of the kind has for years past. His observations were made two years ago, and were noticed as of importance, first by Ernst Haeckel, of Jena, Darwin's great champion and exponent in Germany. Now Professor Kupffer, of Kiel, confirms Kowalevsky's statements, and more credence and attention will be daily given to them. It has been long known that the larvæ of certain Ascidians, when minute free-swimming creatures, have somewhat the aspect of tadpoles, having like them a long swimming tail. This tail has a firm gelatinous rod running along it and projecting into the body of the larva. Now in all vertebrates one of the earliest structures elaborated in the course of development is a long cartilaginous rod, which runs from the tip of the tail to a point near the middle of the head, and round this, which is called the "notochord," bones and muscles develop. It is however an essential and most important feature in vertebrates, that by the rising-up and closing-in of the walls of the body above this notochord a tube is formed, which becomes the great cerebro-spinal nerve-organ, whilst below this axial rod the viscera and blood-vessels lie in a second tube, formed by the closing-in of the walls of the body below the notochord. Now it is a very remarkable fact that the nervous system in these young Ascidians is seen to lie over the gelatinous rod which runs along their tails, whilst the heart and viscera lie below it. The mode of formation of the nerve-system as described by Kowalevsky and Kupffer is the same as that seen in Vertebrata, that is, there is a rising-up of the embryonic walls to enclose a cavity, and though this part of the observations is not quite definite, it certainly appears as a long fusiform vesicle, which stretches its length through the embryonic Ascidian, being connected with a much larger vesicle anteriorily. It does not seem improbable to the believers in evolution that these structures in the embryo Ascidian represent some distant connection in development between them and the Vertebrata. More has to be looked for on this matter, and it is a subject for congratulation that the same brilliant observer, M. Kowalevsky, who has drawn attention to these facts as to Ascidians, should in the same year have furnished us with a most valuable account of the development of the lowest vertebrate, viz. *Amphioxus*, the history of which was previously unknown.

The Significance of Cranial Characters in Man.—Professor John Cleland (spoken of by mistake in our report of the British Association Meeting as Professor McClellan) has communicated to the Royal Society a paper in which he gives an account of some careful investigations into the cranial measurements of various races, and criticizes the various methods of craniometry in use—pointing out what facts of growth and relation of parts the observed measurements really indicate. He observes that if the terms dolichocephalic and brachycephalic are to retain any scientific value, as applied to skulls, the "cephalic index" (that is, the breadth in terms of the length which is called 100) must not be depended on. Other points of importance, as pointed out by Retzius, must be attended to. According to Dr. Cleland, the relation of the height to length of a skull is of great importance. There is no foundation whatever for the supposition, which is a wide-spread one, that the lower races of humanity have the forehead less developed than the more civilized nations; neither is it the case that the forehead slopes more backwards on the floor of the anterior part of the brain-case in them than it does in others.

Diatom Markings and Podura-scale Markings.—The Rev. J. B. Reade, by the use of a very admirable reflecting medium, *viz.* a prism—constructed by Mr. Highley, of London—has been able to demonstrate satisfactorily that the so-called hexagonal markings of diatoms are, as Mr. Wenham had previously urged from investigating splintered bits of diatom-valves, simply hemispherical close-set tubercles. Dr. Royston Pigott, of Halifax, had, curiously enough a little before Mr. Reade, come to the conclusion that the well-known markings of the Podura-scale are caused by a series of spherical "beads" placed in the substance of the scale, which so act on the light as to produce the effect known to all microscopists. Dr. Royston Pigott has examined the subject with exceeding care, having had a $\frac{1}{16}$th especially constructed for his use, and availing himself of great mathematical knowledge in discussing the optical problems involved.

Literature.—The reader is reminded of the 'Record of Zoological Literature', part of which is now ready, and which to increase its usefulness is now brought out in three separate volumes, so that those interested in a special department may obtain a complete and reliable record of what has been written concerning it during 1868, without being encumbered by other matter.—M. Pollen, with the aid of several illustrious Dutch professors of Natural History, is publishing at Leyden an elaborate work on 'The Fauna of Madagascar and the neighbouring Islands,' where he spent some years exploring and collecting.—A new work by Mr. Darwin, 'On Man,' is stated by 'The Academy' to be in preparation.

Memorial to Dr. Sharpey.—A physiological laboratory and scholarship and a portrait and bust of Dr. Sharpey are now being subscribed for by old and present students of University College, London, and by others interested in physiological research, and who value the teaching and influence of Dr. Sharpey in this country; the object of the subscription being to do honour to Dr. Sharpey, and to form a species of testimonial or memorial to him. There is not in England a single laboratory of experimental physiology properly worked and used for the education of students. It is to be hoped that the proposed Sharpey laboratory may form an example to be followed elsewhere. A distinguished German physiologist lately observed upon the strangeness of the fact, that in England we produce absolutely no physiologists in the strict sense. This may be due to the want of laboratories, which are provided by the State in other countries.

Quarterly List of Publications received for Review.

1. The Life and Letters of Faraday. By Dr. Bence Jones, Secretary of the Royal Institution. 2 vols. *Illustrated.*
Longmans, Green, & Co.
2. Elements of Chemistry: Theoretical and Practical. By William Allen Miller, M.D., L.L.D., V.P.R.S. Fourth Edition, with Additions. Part III., Organic Chemistry.
Longmans, Green, & Co.
3. Exercises in Practical Chemistry. By A. G. Vernon Harcourt, M.A., F.R.S., and H. G. Madan, M.A., F.C.S. Series I. Qualitative Exercises. *Clarendon Press.*
4. Essays on Physiological Subjects. By Gilbert W. Child, M.A., F.L.S., &c. Second Edition, with Additions.
Longmans, Green, & Co.
5. Twelve Lectures on Primitive Civilizations and their Physical Conditions. By John P. Mahaffy, A.M. *Longmans & Co.*
6. The Science of Arithmetic: a Systematic Course of Numerical Reasoning and Computation. By James Cornewell, Ph.D., and J. G. Fitch, M.A. *Simpkin, Marshall, & Co*
7. The School Arithmetic. By James Cornewell, Ph.D., and J. G. Fitch, M.A. *Simpkin, Marshall, & Co.*
8. Studies of the Land and Tenantry of Ireland. By B. Samuelson, M.P. *Longmans, Green, & Co.*
9. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By William Crookes, F.R.S., &c., and Ernst Röhrig, Ph.D., M.E. Vol. III. Steel, Fuel, Supplements. *With* 145 *Woodcuts.* *Longmans & Co.*
10. Chemistry for Schools. By C. Houghton Gill, Assistant-Examiner in Chemistry at the University of London. *With* 100 *Illustrations.* *James Walton.*
11. Burton-on-Trent. Its History, its Waters, and its Breweries. By William Molyneux, F.G.S. *Trübner & Co.*
12. Index to the Fossil Remains of Aves, Ornithosauria, and Reptilia, from the Secondary System of Strata. Arranged in the Woodwardian Museum, Cambridge. By H. G. Seeley.
Cambridge: Deighton, Bell, & Co.

13. The Rise and Progress of Manufactures and Commerce, and of Civil and Mechanical Engineering in Lancashire and Cheshire. By William Fairbairn, C.E., LL.D., F.R.S. (now Sir William Fairbairn, Bart.).

PAMPHLETS AND PERIODICALS.

Mineral Statistics of the United Kingdom for the Year 1868. By Robert Hunt, F.R.S., Keeper of the Mining Records. (Memoirs of the Geological Survey.) *Longmans.*

The Triassic and Permian Rocks of the Midland Counties of England. By Ed. Hull, M.A., F.R.S. (Memoirs of Geological Survey.)

The Lichen Flora of Greenland. By W. Lauder Lindsay, M.D.

On the Geographical Distribution of Coniferæ and Gnetaceæ. By Robert Brown, F.R.G.S.

Introductory Lecture at the Royal College of Science, Ireland. By Ed. Hull, F.R.S., Director of the Geological Survey of Ireland.

The Land Question in Ireland. By B. B. Stoney, M.B., M.I.C.E.

The Examination of Petroleum and other Mineral Oils according to the Petroleum Act, 1868. By A. Norman Tate.

A Trip to America. By James Howard, M.P., Bedford.

The Alexandra College, Dublin. Programme and Synopsis of Lectures to Ladies. (Three Pamphlets.)

On the Continuity of the Gaseous and Liquid States of Matter. By Thomas Andrews, M.A., F.R.S. Bakerian Lecture.

Methods of Teaching Arithmetic. By J. G. Fitch, M.A. *Stanford.*

Introductory Address delivered at the Royal Infirmary School of Medicine, October 1st, 1869. By A. Davison, M.A., M.D. *Liverpool: Adam Holden.*

The Working Man's School. By W. J. Kennedy, M.A. *Longmans.*

The Popularity of Error and the Unpopularity of Truth. By John Hampden, Esq.

A Brief Paper on the Pathology of Insanity. By R. C. Shettle, M.D., Physician to the Royal Berks Hospital.

The Canadian Naturalist and Geologist. (With the Proceedings of the Natural History Society of Montreal.)

The Liverpool Medical and Surgical Reports. Edited by P. M. Braidwood, M.D., and Reginald Harrison, F.R.C.S.

The Geological Magazine.

The British and Foreign Mechanic.

The Quarterly Journal of Microscopical Science. *J. Churchill & Sons.*

Revue Bibliographique Universelle.

Cosmos.

Journal of Applied Chemistry, published simultaneously in New York, Philadelphia, and Boston.

The American Naturalist.

Van Nostrand's Eclectic Engineering.

Scientific Opinion.

The Gardener's Magazine.

The Civil Service Gazette.

The Westminster Review.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Öfversigt af Kongl: Vetenskaps-Akademiens Förhandlingar.
Stockholm: Norstedt & Söner.

The Journal of the Historical and Archæological Association of Ireland.

Journal of the Farmers' Club.

Proceedings of the Royal Society.

" " Royal Astronomical Society.

TO ADVERTISERS.

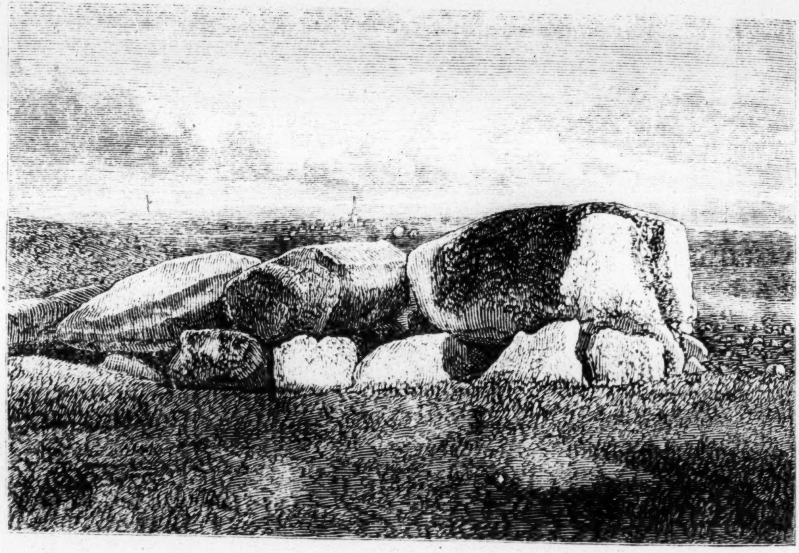
QUARTERLY JOURNAL OF SCIENCE.

SCALE OF CHARGES.

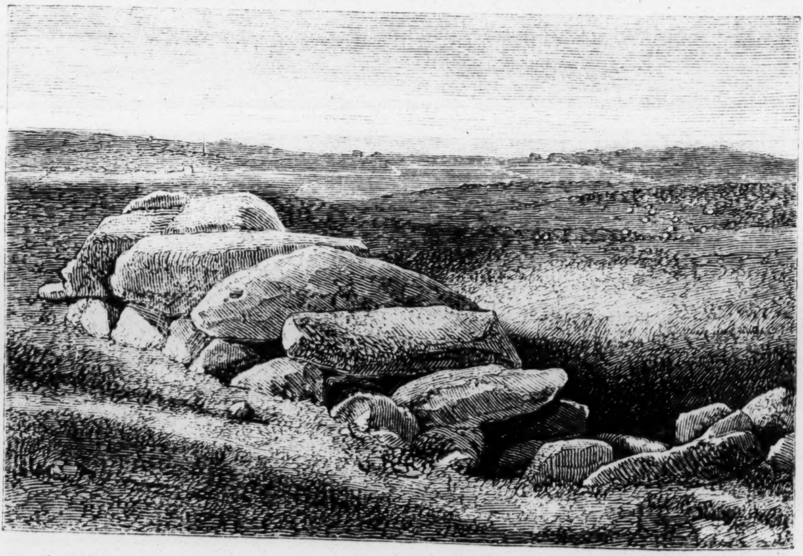
	£.	s.	d.
Eighth of a Page, or under	0	6	0
Quarter of a Page	0	11	6
Half a Page	1	1	0
A Page	2	0	0
Bills inserted	2	2	0

NOTICE TO AUTHORS.

⁂ Authors of Original Papers wishing Reprints for private circulation may have them on application to the Printers of the Journal, Messrs. W. Clowes & Sons, 14, Charing Cross, S.W., at a fixed charge of 30*s.* per sh[illegible] per 100 copies, including a Coloured Wrapper and Title Page, *but such Reprints will not be delivered to Contributors till* One Month *after publication of the Number containing their Paper, and the Reprints must be ordered before the expiration of that period.*



L'Ancresse. No. 1.



L'Ancresse. No. 2.